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AUTHOR	Bussey, Margery Koo
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ABSTRACT

This Unified Sciences and Mathematics for Elementary Schools (USMES) unit challenges students to find good ways to protect property (property in desks or lockers; animals; bicycles; tools). The challenge is general enough to apply to many problem-solving situations in mathematics, science, social science, and language arts at any elementary school level (grades 1-8). The Teacher Resource Book for the unit is divided into five sections. Section I describes the USMES approach to student-initiated investigations of real problems, including a discussion of the nature of USMES "challenges." Section II provides an overview of possible student activities with comments on prerequisite skills, instructional strategies, suggestions when using the unit with primary grades, a flow chart illustrating how investigations evolve from students' discussions of the problems, and a hypothetical account of intermediate-level class activities. Section III provides documented events of actual class activities from grades 4, 5, and 6. Section IV includes lists of "How To" cards and background papers, bibliography of non-USMES materials, and a glossary. Section V consists of charts identifying skills, concepts, processes, and areas of study learned as students become involved with the activities. (JN)

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Contributors

USMES Central Staff

Earle Lomon, *Project Director*
Betty M. Beck, *Associate Director for Development*
Quinton Baker, *Associate Director for Administration*
L. Ray Brady, Jr., *Editor/Production Manager*
Margery Koo Bussey, Lynn Hildebrandt, *Associate Editors*
John W. Saalfield, *Graphic Design*
Martha Allegro, Nancy Brady, Lois Finstein, Elizabeth Barringer; Florence Preman, Lois Lapeza, *Administrative Staff*

University Content and Curriculum Specialists

Bruce Cheney, Michigan State University, East Lansing, MI
Edward Liddle, Oakland University, Rochester, MI
David Ost, California State College, Bakersfield, CA
Dale Padgitt, Bell Telephone Labs, Holmdel, NJ
Thacher Robinson, Washington School, Champaign, IL

Classroom Teachers

Barbara Briggs, Washington School, Plainfield, NJ
William Cowley, Jr., North School, Lansing, MI
Philip Dershem, Marina Vista School, Monterey, CA
Charles Donahoe, Dearborn School, Boston, MA
Peter Halgemo, Maple Hill School, Lansing, MI
Stephen Hanson, Monte Vista School, Monterey, CA
William Henderson, Washington School, Champaign, IL
Keith Heslip, Platt Junior High School, Boulder, CO
Loren Honn, Washington School, Champaign, IL
Joseph Joyce, John Winthrop School, Boston, MA
Marilyn Keohan, Adams School, Lexington, MA
Lucy Knappen, Morse Park School, Lansing, MI
Carol Lamagna, Everett School, Lansing, MI
Regina Lauterbach, Marina Vista School, Monterey, CA
John Limon, Heatherwood School, Boulder, CO
Laura Lyon, Heatherwood School, Boulder, CO
Charles McNeilly, Pleasantview School, Lansing, MI
Kathryn McNenly, Allen Street School, Lansing, MI
Mary Jones Palsulich, Heatherwood School, Boulder, CO
Norma Rasch, Cavanaugh School, Lansing, MI
Marie Salah, Hosmer School, Watertown, MA
Vito Sammarco, Brackett School, Arlington, MA
Arthur Shaw, Stratton School, Arlington, MA
Katharine Snavely, Virginia Avenue School, Petersburg, VA
Yvonne Thorne, Walker-Jones Elementary School, Washington, DC
Mary Ellen Warner, Wallace Middle School, Charleston, SC
Barbara Waterston, Vista View School, Burnsville, MN
Roy White, Paul Revere Elementary School, Chicago, IL
Franklin Yates, Lyndale School, Minneapolis, MN

This edition of Protecting Property written and edited by Margery Koo Bussey, supervising editors Betty M. Beck and L. Ray Brady, Jr. Production work performed by Margery Koo Bussey, L. Ray Brady, Jr., and Martha Allegro. Cover design by John W. Saalfield.

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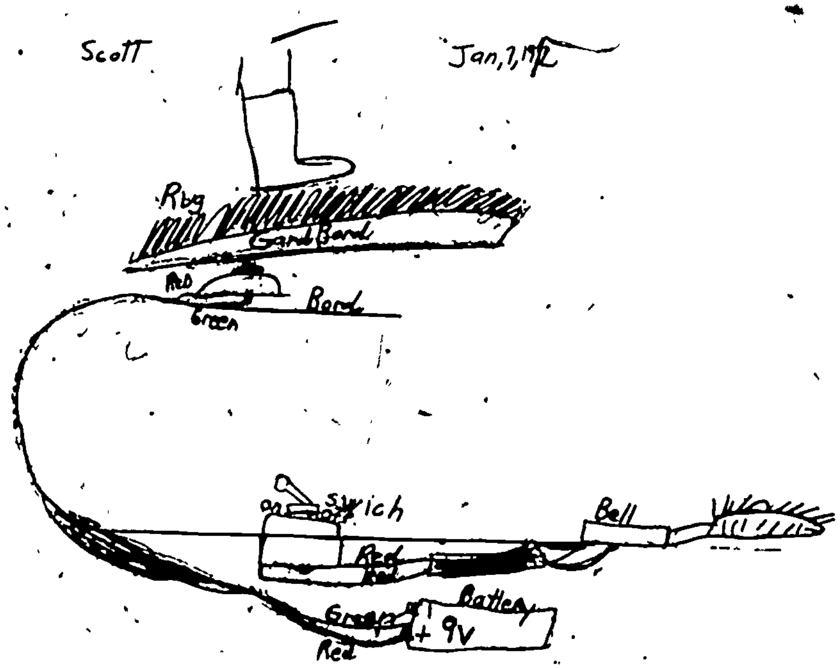
Mathematics and the Natural, Social, and Communications Sciences in
Real Problem Solving

Protecting Property

First Edition



Education Development Center, Inc.
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Trial Edition

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The present edition has been revised to include other means of protecting property besides alarms

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CHALLENGE: FIND A GOOD WAY TO PROTECT YOUR __________(PROPERTY IN DESKS OR LOCKERS, BIKES, TOOLS, ANIMALS, ETC.)

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Preface

The USMES Project

Unified Sciences and Mathematics for Elementary Schools: Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving (USMES) was formed in response to the recommendations of the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools.* Since its inception in 1970, USMES has been funded by the National Science Foundation to develop and carry out field trials of interdisciplinary units centered on long-range investigations of real and practical problems (or "challenges") taken from the local school/community environment. School planners can use these units to design a flexible curriculum for grades one through eight in which real problem solving plays an important role.

Development and field trials were carried out by teachers and students in the classroom with the assistance of university specialists at workshops and at occasional other meetings. The work was coordinated by a staff at the Education Development Center in Newton, Massachusetts. In addition, the staff at EDC coordinated implementation programs involving schools, districts, and colleges that are carrying out local USMES implementation programs for teachers and schools in their area.

Trial editions of the following units are currently available:

Advertising	Nature Trails
Bicycle Transportation	Orientation
Classroom Design	Pedestrian Crossings
Classroom Management	Play Area Design and Use
Consumer Research	Protecting Property
Describing People	#School Rules
Designing for Human Proportions	School Supplies
#Design Lab Design	School Zoo
#Eating in School	Soft Drink Design
Getting There	Traffic Flow
Growing Plants	#Using Free Time
Manufacturing	Ways to Learn/Teach
Mass Communications	Weather Predictions

*See *Goals for the Correlation of Elementary Science and Mathematics*, Houghton Mifflin Co., Boston, 1969.

#Available fall 1976.

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USMES Resources

In responding to a long-range challenge, the students and teachers often have need of a wide range of resources. In fact, all of the people and materials in the school and community are important resources for USMES activities. USMES provides resources in addition to these. One resource for students is the Design Lab or its classroom equivalent: using the tools and supplies available, children can follow through on their ideas by constructing measuring tools, testing apparatus, models, etc. Another resource for students is the *"How To" Cards*. Each set of cards gives information about a specific problem; the students use a set only when they want help on that particular problem.

Several types of resources are available for teachers: the *USMES Guide*, a *Teacher Resource Book* for each challenge, *Background Papers*, a *Design Lab Manual*, and a *Curriculum Correlation Guide*. A complete set of all these written materials comprise what is called the USMES library. This library, which should be available in each school using USMES units, contains the following:

1. *The USMES Guide*

   The USMES Guide is a compilation of materials that may be used for long-range planning of a curriculum that incorporates the USMES program. In addition to basic information about the project, the challenges, and related materials, it contains charts assessing the strengths of the various challenges in terms of their possible subject area content.

2. *Teacher Resource Books* (one for each challenge)

   Each book contains a description of the USMES approach to real problem-solving activities, general information about the particular unit, edited logs of class activities, other written materials relevant to the unit, and charts that indicate the basic skills, processes, and areas of study that may be learned and utilized as students become engaged in certain possible activities.

3. *Design Lab Manual*

   This contains sections on the style of Design Lab activities, safety considerations, and an inventory

of tools and supplies. Because many "hands-on" activities may take place in the classroom, the Design Lab Manual should be made available to each USMES teacher.

4. *"How To" Cards*

These short sets of cards provide information to students about specific problems that may arise during USMES units. Particular computation, graphing, and construction problems are discussed. A complete list of the "How To" Cards can be found in the USMES Guide.

5. *Background Papers*

These papers are written to provide information for the teachers on technical problems that might arise as students carry on various investigations. A complete list of the Background Papers can be found in the USMES Guide.

6. *Curriculum Correlation Guide*

This volume is intended to coordinate other curriculum materials with the Teacher Resource Books and to provide the teacher with the means to integrate USMES easily into other school activities and lessons.

The preceding materials are described in brief in the USMES brochure, which can be used by teachers and administrators to disseminate information about the program to the local community. A variety of other dissemination and implementation materials are also available for individuals and groups involved in local implementation programs. They include *Preparing People for USMES: An Implementation Resource Book*, the USMES slide/tape show, the Design Lab slide/tape show, the Design Lab brochure, the USMES newsletter, videotapes of classroom activities, a general report on evaluation results, a map showing the locations of schools conducting local implementation of USMES, a list of experienced USMES teachers and university consultants, and newspaper and magazine articles.

Acknowledgments

Besides the contributors listed at the beginning of the book, we are deeply indebted to the many elementary school

children whose investigations of the challenge form the basis for this book. Without their efforts this book would not have been possible. Many thanks to the Planning Committee for their years of service and advice. Many thanks also to other members of the USMES staff for their suggestions and advice and for their help in staffing and organizing the development workshops. Special thanks also go to Christopher Hale for his efforts as Project Manager during the development of this book.

* * *

Because Tri-Wall was the only readily available brand of three-layered cardboard at the time the project began, USMES has used it at workshops and in schools; consequently, references to Tri-Wall can be found throughout the Teacher Resource Books. The addresses of companies that supply three-layered cardboard can be found in the Design Lab Manual.

Introduction

Using the Teacher Resource Book

When teachers try a new curriculum for the first time, they need to understand the philosophy behind the curriculum. The USMES approach to student-initiated investigations of real problems is outlined in section A of this Teacher Resource Book.

Section B starts with a brief overview of possible student activities arising from the challenge; comments on prerequisite skills are included. Following that is a discussion of the classroom strategy for USMES real problem-solving activities, including introduction of the challenge, student activity, resources, and Design Lab use. Subsequent pages include a description of the use of the unit in primary grades, a flow chart and a composite log that indicate the range of possible student work, and a list of questions that the teacher may find useful for focusing the students' activities on the challenge.

Because students initiate all the activities in response to the challenge and because the work of one class may differ from that undertaken by other classes, teachers familiar with USMES need to read only sections A and B before introducing the challenge to students.

Section C of this book is the documentation section. These edited teachers' logs show the variety of ways in which students in different classes have worked at finding a solution to the challenge.

Section D contains a list of the titles of relevant sets of "How To" Cards and brief descriptions of the Background Papers pertaining to the unit. Also included in section D is a glossary of the terms used in the Teacher Resource Book and an annotated bibliography.

Section E contains charts that indicate the comparative strengths of the unit in terms of real problem solving, mathematics, science, social science, and language arts. It also contains a list of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in the unit. These charts and lists are based on documentation of activities that have taken place in USMES classes. Knowing ahead of time which basic skills and processes are likely to be utilized, teachers can postpone teaching that part of their regular program until later in the year. At that time students can study them in the usual way if they have not already learned them as part of their USMES activities.

A. Real Problem Solving and USMES

*If life were of such a constant nature that there were only a few chores to do and they were done over and over in exactly the same way, the case for knowing how to solve problems would not be so compelling. All one would have to do would be to learn how to do the few jobs at the outset. From then on he could rely on memory and habit. Fortunately--or unfortunately depending upon one's point of view--life is not simple and unchanging. Rather it is changing so rapidly that about all we can predict is that things will be different in the future. In such a world the ability to adjust and to solve one's problems is of paramount importance.**

Real Problem Solving

USMES is based on the beliefs that real problem solving is an important skill to be learned and that many math, science, social science, and language arts skills may be learned more quickly and easily within the context of student investigations of real problems. Real problem solving, as exemplified by USMES, implies a style of education which involves students in investigating and solving real problems. It provides the bridge between the abstractions of the school curriculum and the world of the student. Each USMES unit presents a problem in the form of a challenge that is interesting to children because it is both real and practical. The problem is real in several respects: (1) the problem applies to some aspect of student life in the school or community, (2) a solution is needed and not presently known, at least for the particular case in question, (3) the students must consider the entire situation with all the accompanying variables and complexities, and (4) the problem is such that the work done by the students can lead to some improvement in the situation. This expectation of useful accomplishment provides the motivation for children to carry out the comprehensive investigations needed to find some solution to the challenge.

The level at which the children approach the problems, the investigations that they carry out, and the solutions

*Kenneth B. Henderson and Robert E. Pingry, "Problem-Solving in Mathematics," in *The Learning of Mathematics: Its Theory and Practice,* Twenty-first Yearbook of the National Council of Teachers of Mathematics (Washington, D.C.: The Council, 1953), p. 233.

that they devise may vary according to the age and ability of the children. However, real problem solving involves them, at some level, in all aspects of the problem-solving process: definition of the problem; determination of the important factors in the problem; observation; measurement; collection of data; analysis of the data using graphs, charts, statistics, or whatever means the students can find; discussion; formulation and trial of suggested solutions; clarification of values; decision making; and communications of findings to others. In addition, students become more inquisitive, more cooperative in working with others, more critical in their thinking, more self-reliant, and more interested in helping to improve social conditions.

The USMES Approach

To learn the process of real problem solving, the students must encounter, formulate, and find some solution to complete and realistic problems. The students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of their hypotheses and conclusions. In real problem-solving activities, the teacher acts as a coordinator and collaborator, not an authoritative answer-giver.

The problem is first reworded by students in specific terms that apply to their school or community, and the various aspects of the problem are discussed by the class. The students then suggest approaches to the problem and set priorities for the investigations they plan to carry out. A typical USMES class consists of several groups working on different aspects of the problem. As the groups report periodically to the class on their progress, new directions are identified and new task forces are formed as needed. Thus, work on an USMES challenge provides students with a "discovery-learning" or "action-oriented" experience.

Real problem solving does not rely solely on the discovery-learning concept. In the real world people have access to certain facts and techniques when they recognize the need for them. The same should be true in the classroom. When the students find that certain facts and skills are necessary for continuing their investigation, they learn willingly and quickly in a more directed way to acquire these facts and skills. Consequently, the students should have available different resources that they may use as they recognize the need for them, but they should still be left with a wide scope to explore their own ideas and methods.

Certain information on specific skills is provided by the sets of USMES "How To" Cards. The students are referred only to the set for which they have clearly identified a need and only when they are unable to proceed on their own. Each "How To" Cards title clearly indicates the skill involved--"How to Use a Stopwatch," "How to Make a Bar Graph Picture of Your Data," etc. (A complete list of the "How To" Cards can be found in Chapter IX of the USMES Guide.)

Another resource provided by USMES is the Design Lab or its classroom equivalent. The Design Lab provides a central location for tools and materials where devices may be constructed and tested without appreciably disrupting other classroom activities. Ideally, it is a separate room with space for all necessary supplies and equipment and work space for the children. However, it may be as small as a corner of the classroom and may contain only a few tools and supplies. Since the benefits of real problem solving can be obtained by the students only if they have a means to follow up their ideas, the availability of a Design Lab can be a very important asset.

Optimally, the operation of the school's Design Lab should be such as to make it available to the students whenever they need it. It should be as free as possible from set scheduling or programming. The students use the Design Lab to try out their own ideas and/or to design, construct, test, and improve many devices initiated by their responses to the USMES challenges. While this optimum operation of the Design Lab may not always be possible due to various limitations, "hands-on" activities may take place in the classroom even though a Design Lab may not be available. (A detailed discussion of the Design Lab can be found in Chapter VI of the USMES Guide, while a complete list of "How To" Cards covering such Design Lab skills as sawing, gluing, nailing, soldering, is contained in Chapter IX.)

Work on all USMES challenges is not only sufficiently complex to require the collaboration of the whole class but also diverse enough to enable each student to contribute according to his/her interest and ability. However, it should be noted that if fewer than ten to twelve students from the class are carrying out the investigation of a unit challenge, the extent of their discovery and learning can be expected to be less than if more members of the class are involved. While it is possible for a class to work on two related units at the same time, in many classes the students progress better with just one.

The amount of time spent each week working on an USMES challenge is crucial to a successful resolution of the

problem. Each challenge is designed so that the various investigations will take from thirty to forty-five hours, depending on the age of the children, before some solution to the problem is found and some action is taken on the results of the investigations. Unless sessions are held at least two or three times a week, it is difficult for the children to maintain their interest and momentum and to become involved intensively with the challenge. The length of each session depends upon the age level of the children and the nature of the challenge. For example, children in the primary grades may proceed better by working on the challenge more frequently for shorter periods of time, perhaps fifteen to twenty minutes, while older children may proceed better by working less frequently for much longer periods of time.

Student interest and the overall accomplishments of the class in finding and implementing solutions to the challenge indicate when the class's general participation in unit activities should end. (Premature discontinuance of work on a specific challenge is often due more to waning interest on the part of the teacher than to that of the students.) However, some students may continue work on a voluntary basis on one problem, while the others begin to identify possible approaches to another USMES challenge.

Importance of the Challenge

Although individual (or group) discovery and student initiation of investigations is the process in USMES units, this does not imply the constant encouragement of random activity. Random activity has an important place in children's learning, and opportunities for it should be made available at various times. During USMES activities, however, it is believed that children learn to solve real problems only when their efforts are focused on finding some solution to the real and practical problem presented in the USMES challenge. It has been found that students are motivated to overcome many difficulties and frustrations in their efforts to achieve the goal of effecting some change or at least of providing some useful information to others. Because the children's commitment to finding a solution to the challenge is one of the keys to successful USMES work, it is extremely important that the challenge be introduced so that it is accepted by the class as an important problem to which they are willing to devote a considerable amount of time.

The challenge not only motivates the children by stating the problem but also provides them with a criterion for judging their results. This criterion--if it works, it's right (or if it helps us find an answer to our problem, it's

a good thing to do)--gives the children's ideas and results a meaning within the context of their goal. Many teachers have found this concept to be a valuable strategy that not only allows the teacher to respond positively to all of the children's ideas but also helps the children themselves to judge the value of their efforts.

Role of the Teacher

With all of the above in mind, it can be said that the teacher's responsibility in the USMES strategy for open classroom activities is as follows:

1. Introduce the challenge in a meaningful way that not only allows the children to relate it to their particular situation but also opens up various avenues of approach.

2. Act as a coordinator and collaborator. Assist, not direct, individuals or groups of students as they investigate different aspects of the problem.

3. Hold USMES sessions at least two or three times a week so that the children have a chance to become involved in the challenge and carry out comprehensive investigations.

4. Provide the tools and supplies necessary for initial hands-on work in the classroom or make arrangements for the children to work in the Design Lab.

5. Be patient in letting the children make their own mistakes and find their own way. Offer assistance or point out sources of help for specific information (such as the "How To" Cards) only when the children become frustrated in their approach to the problem. Conduct skill sessions as necessary.

6. Provide frequent opportunities for group reports and student exchanges of ideas in class discussions. In most cases, students will, by their own critical examination of the procedures they have used, improve or set new directions in their investigations.

7. If necessary, ask appropriate questions to stimulate the students' thinking so that they will make more extensive and comprehensive investigations or analyses of their data.

8. Make sure that a sufficient number of students (usually ten to twelve) are working on the challenge so that activities do not become fragmented or stall.

Student success in USMES unit activities is indicated by the progress they make in finding some solution to the challenge, not by following a particular line of investigation nor by obtaining specified results. The teacher's role in the USMES strategy is to provide a classroom atmosphere in which all students can, in their own way, search out some solution to the challenge.

USMES in the Total School Program

Today many leading educators feel that real problem solving (under different names) is an important skill to be learned. In this mode of learning particular emphasis is placed on developing skills to deal with real problems rather than the skills needed to obtain "correct" answers to contrived problems. Because of this and because of the interdisciplinary nature of both the problems and the resultant investigations, USMES is ideal for use as an important part of the elementary school program. Much of the time normally spent in the class on the traditional approaches to math, science, social science, and language arts skills can be safely assigned to USMES activities. In fact, as much as one-fourth to one-third of the total school program might be allotted to work on USMES challenges. Teachers who have worked with USMES for several years have each succeeding year successfully assigned to USMES activities the learning of a greater number of traditional skills. In addition, reports have indicated that students retain for a long time the skills and concepts learned and practiced during USMES activities. Therefore, the time normally spent in reinforcing required skills can be greatly reduced if these skills are learned and practiced in the context of real problem solving.

Because real problem-solving activities cannot possibly cover all the skills and concepts in the major subject areas, other curricula as well as other learning modes (such as "lecture method," "individual study topics," or programmed instruction) need to be used in conjunction with USMES in an optimal education program. However, the other

instruction will be enhanced by the skills, motivation, and understanding provided by real problem solving, and, in some cases, work on an USMES challenge provides the context within which the skills and concepts of the major subject areas find application.

In order for real problem solving taught by USMES to have an optimal value in the school program, class time should be apportioned with reason and forethought, and the sequence of challenges investigated by students during their years in elementary school should involve them in a variety of skills and processes. Because all activities are initiated by students in response to the challenge, it is impossible to state unequivocally which activities will take place. However, it is possible to use the documentation of activities that have taken place in USMES trial classes to schedule instruction on the specific skills and processes required by the school system. Teachers can postpone the traditional way of teaching the skills that might come up in work on an USMES challenge until later in the year. At that time students can learn the required skills in the usual way if they have not already learned them during their USMES activities.

These basic skills, processes, and areas of study are listed in charts and lists contained in each Teacher Resource Book. A teacher can use these charts to decide on an overall allocation of class time between USMES and traditional learning in the major subject disciplines. Examples of individual skills and processes are also given so that the teacher can see beforehand which skills a student may encounter during the course of his investigations. These charts and lists may be found in section E.

Ways In Which USMES Differs From Other Curricula

As the foregoing indicates, USMES differs significantly from other curricula. Real problem solving develops the problem-solving ability of students and does it in a way (learning-by-doing) that leads to a full understanding of the process. Because of the following differences, some teacher preparation is necessary. Some teachers may have been introduced by other projects to several of the following new developments in education, but few teachers have integrated all of them into the new style of teaching and learning that real problem solving involves.

1. New Area of Learning--Real problem solving is a new area of learning, not just a new approach or a new content within an already-defined subject area. Although many subject-matter curricula

include something called problem solving, much of this problem solving involves contrived problems or fragments of a whole situation and does not require the cognitive skills needed for the investigation of real and practical problems. Learning the cognitive strategy required for real problem solving is different from other kinds of learning.

3. Interdisciplinary Education--Real problem solving integrates the disciplines in a natural way; there is no need to impose a multi-disciplinary structure. Solving real and practical problems requires the application of skills, concepts, and processes from many disciplines. The number and range of disciplines are unrestricted and the importance of each is demonstrated in working toward the solution of practical problems.

3. Student Planning--To learn the process of problem solving, the students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of the hypotheses and conclusions. In real problem-solving activities the teacher acts as a coordinator and collaborator, not as an authoritative source of answers.

4. Learning-by-Doing--Learning-by-doing, or discovery learning as it is sometimes called, comes about naturally in real problem solving since the problems tackled by each class have unique aspects; for example, different lunchrooms or pedestrian crossings have different problems associated with them and, consequently, unique solutions. The challenge, as defined in each situation, provides the focus for the children's hands-on learning experiences, such as collecting real data; constructing measuring instruments, scale models, test equipment, etc.; trying their suggested improvements; and (in some units) preparing reports and presentations of their findings for the proper authorities.

5. Learning Skills and Concepts as Needed--Skills and concepts are learned in real problem solving

as the need for them arises in the context of the work being done, rather than having a situation imposed by the teacher or the textbook being used. Teachers may direct this learning when the need for it arises, or students may search out information themselves from resources provided.

6. Group Work--Progress toward a solution to a real problem usually requires the efforts of groups of students, not just individual students working alone. Although some work may be done individually, the total group effort provides good opportunities for division of labor and exchange of ideas among the groups and individuals. The grouping is flexible and changes in order to meet the needs of the different stages of investigation.

7. Student Choice--Real problem solving offers classes the opportunity to work on problems that are real to them, not just to the adults who prepare the curriculum. In addition, students may choose to investigate particular aspects of the problem according to their interest. The variety of activities ensuing from the challenge allows each student to make some contribution towards the solution of the problem according to his or her ability and to learn specific skills at a time when he or she is ready for that particular intellectual structure.

B. General Papers on Protecting Property

1. OVERVIEW OF ACTIVITIES

Challenge:

Find a good way to protect your ___________ (property in desks or lockers, bikes, tools, animals, etc.).

Possible Class Challenges:

How can we protect our bicycles?

How can we keep things from being taken from the Design Lab?

Design a good system that will prevent the loss of articles from our lockers.

Finding a solution to the Protecting Property challenge becomes a real problem to students in some classes when they experience a loss of property from their desks or lockers. In other classes the need to protect bicycles or pets in cages is more important. For still other students the problem becomes real when they find only a few tools or materials left in the Design Lab for their use.

After identifying one or several problems as most urgent, the students may break into small groups to sketch their ideas of alarms and security containers, such as lockers and safes. Some classes may examine different kinds of security methods used in public buildings, such as schools, stores, and apartment buildings. A discussion of these initial sketches and observations may help the class to determine which security method is feasible for them to build or to use to resolve their problem. If some students sketch a mechanical alarm system, such as a pail of marbles tipping over when a door is opened, the class may soon determine the disadvantages of such a design. Some students may also realize that their particular designs of lockers or safes cannot be feasibly constructed.

Students making lockers and safes become involved with the mechanics of making a sturdy and secure container. Latches and hinges may be bought or designed and constructed by the students. Padlocks or a burglar alarm may be used to make containers secure. Those who construct burglar alarms deal with electric circuits and their components (bulbs, buzzers, switches, batteries, wire), and students unfamiliar with electricity may wish first to experiment briefly with electric circuits. They may then construct simple alarms for their desks or lockers. Instead of making containers or alarms, some students may set up a procedure for making random checks of their property, while other students may develop an advertising campaign to warn others that security methods are being employed.

The students' descriptions of their devices, containers, or other security methods stimulate class discussions and the subsequent design of more sophisticated devices or procedures. Alarms such as floor alarms or complicated alarms involving two circuits and an electromagnet or a relay may be constructed; other containers and locks may be tried, and other systems for checking property may be set up. Improve-

ments to the alarms and containers are made as problems with durability and convenience come up. As each improvement is made, the students may collect data on the effectiveness of the method in protecting their property.

The students' activities in Protecting Property may lead naturally to other USMES challenges. Their interest in particular areas of the school may lead to units such as Design Lab Design, Classroom Management, Classroom Design; they may also become involved with other aspects of Bicycle Transportation. The other USMES units that could evolve from the Protecting Property unit include Consumer Research (to compare various building materials), School Rules (to establish rules for lockers and personal belongings), Advertising, or Mass Communications (to tell others about the security methods being used).

Although many of the activities may require skills and concepts new to the students, there is no need for preliminary work on these skills and concepts because the students can learn them when the need arises. In fact, students learn more quickly and easily when they see a need to learn. Consider the various concepts involving electric circuits: whereas students usually learn these concepts from textbooks, they can, through USMES, gain a better understanding of them by designing and building circuits that have a specific purpose.

2. CLASSROOM STRATEGY FOR PROTECTING PROPERTY

The Protecting Property unit centers on a challenge--a statement that says, "Solve this problem." Its success or failure in a classroom depends largely on (1) the relevance of the problem for the students and (2) the process by which they define and accept the challenge. If the children see the problem as a real one, they will have a focus and purpose for their activities. If the students do not think the problem affects them, their attempts at finding solutions will likely be disjointed and cursory.

One intermediate-grade teacher introduced the Protecting Property challenge to her class soon after school began. The children listed and categorized things that they had lost or that had been taken in the past. They spent several weeks constructing burglar alarms and security containers. The teacher refocused on the challenge several times during the course of their

construction activities. However, because the problem of missing belongings was not urgent to the children, they lacked real motivation. Motivation to finish their alarms and containers came when they decided to show their products at an Open House.

The Protecting Property challenge--"Find a good way to protect your __________ (property in desks or lockers, bikes, tools, animals, etc.)--is general enough to apply to many situations. Students in different classes define and reword the challenge to fit their particular situation and thus arrive at a specific class challenge. For example, the Protecting Property challenge has been restated by one fifth-grade class in terms of finding ways to prevent further stealing of personal things from their tote trays. In another school a group of boys in a fourth-grade class worked on the challenge of protecting the Design Lab tools and materials when the Design Lab manager was away from the room.

The Process of Introducing the Challenge

Given that a problem exists, how can a teacher, without being directive, help the students identify the challenge that they will work on as a group? There is no set method because of variations among teachers, classes, and schools and among the USMES units themselves. However, USMES teachers have found that certain general techniques in introducing the challenge are helpful.

One such technique is to turn a discussion of some recent event toward the challenge. For example, the teacher may focus a discussion of someone's missing lunch money on the Protecting Property challenge.

Since school began, one fifth-grade teacher had received continual complaints about missing personal things from her students. After one such complaint the teacher introduced the challenge. The class identified four problems in the classroom: stolen items from their tote trays (the students had trays instead of desks in which to keep their personal belongings), stolen lunches, stolen lunch boxes, and smashed lunches. A class vote showed that most students felt that the tote tray problem was the most important one.

Often work on one challenge leads to another. For example, a class may have just rearranged the school Design

Lab in response to the Design Lab Design challenge. Not wanting the newly scrounged materials to be stolen, the class may seek effective ways to protect the Design Lab materials.

One sixth-grade class worked on a School Supplies challenge to reopen the school store. They soon realized that they needed security measures to protect the store from theft and vandalism. One group of students designed and installed a security system that protected the supplies inside their display case.

When children encounter a problem that leads to a related USMES challenge, one group of children may begin work on the second challenge while the rest of the class continues with the first challenge. However, there should be at least ten to twelve students working on any one challenge; otherwise, the children's work may be fragmented or superficial or may break down completely.

An USMES challenge may also evolve from a discussion of a specific topic being studied by the class. For example, a class may be studying electricity and its ability to make machines and gadgets operate. Students may become interested in building their own electrical gadget, which may include alarms. A Protecting Property problem may evolve from these activities.

Sometimes the discussion of a broad problem may encompass the challenges of several related units. For example, a discussion of problems in the classroom may lead to Protecting Property, Using Free Time, Classroom Design, Classroom Management, or Designing for Human Proportions. Similarly, a discussion of problems at school could lead to the challenges of Protecting Property (again), School Rules, School Supplies, Eating in School, Orientation, or Play Area Design and Use.

An experienced USMES teacher is usually willing to have the children work on any one of the several challenges that may arise during the discussion of a broad problem. While this approach gives the children the opportunity to select the challenge they are most interested in investigating, it does place on the teacher the additional responsibility of being prepared to act as a resource person for whichever challenge is chosen.

Classroom experience has shown that children's progress on an USMES challenge may be poor if the teacher and students do not reach a common understanding of what the challenge is before beginning work on it. Having no shared

focus for their work, the children will lack the motivation inherent in working together to solve a real problem. As a result, they may quickly lose interest.

A similar situation occurs if the teacher, rather than ensuring that the children have agreed upon a challenge, merely assigns a series of activities. Although the teacher may see how these activities relate to an overall goal, the children may not.

Before introducing the topic of burglar alarms, one fourth-grade teacher had the class proceed through a series of activites. The students first experimented with a battery, a bulb, and a piece of wire. Then they constructed simple circuits and switches, with some students using the "How To" Cards on electricity. To test their knowledge of circuits, each student had to solve the circuits in several inference boxes. Although the class discussed what an alarm was, what its uses were, how alarms might be constructed, and where they might be placed, the students did not discuss any challenge. The class thereafter constructed alarms but for no specific purpose.

Initial Work on the Challenge

Once a class has decided to work on a Protecting Property challenge, USMES sessions should be held several times a week, but they need not be rigidly scheduled. When sessions are held after long intervals, students often have difficulty remembering exactly where they were in their investigations and momentum diminishes.

During the initial session the students list possible ways to protect the things that they have identified as needing protection. They then decide which protection methods are feasible to build or to implement. Small groups are formed to construct alarms and security containers and to develop a system for random checks.

In many classes work on the Protecting Property challenge is done by individuals or small groups as they design their own security methods.

Students in one fifth-grade class worked individually and in twos and threes designing and constructing burglar alarms, lockers, safes, and tote tray lids. As they worked in the Design Lab they exchanged ideas and advice freely.

Refocusing on the Challenge

As the class works on their challenge, the children's attention should, from time to time, be refocused on it so that they do not lose sight of their overall goal. Refocusing is particularly important with younger children because they have a shorter attention span. Teachers find it helpful to hold periodic class discussions that include individual and group reports. Such sessions help the students review what they have accomplished and what they still need to do to implement their security method. These discussions also provide an opportunity for students to participate both in evaluating their own work and in exchanging ideas with their classmates.

After Christmas vacation one fourth- through sixth-grade class reviewed their activities and shared their ideas on alarms. They discussed reasons for the failure of some alarms to work--poor use of conducting materials, excessive wiring, open circuits--and the need for switches. Two boys intrigued the class with their alarm that had a throw switch. The class became excited about incorporating switches into their alarm designs.

Resources for Work on the Challenge

When children encounter difficulties during their work, an USMES teacher helps out. However, instead of giving answers or suggesting specific procedures, the teacher asks open-ended questions that stimulate the students to think more comprehensively and creatively about their work. For example, instead of telling the students why their alarm may be unreliable, the teacher may ask, "How many times will your alarm work without being adjusted?" Examples of other nondirective, thought-provoking questions may be found in section B6 of this resource book.

The teacher may also refer students to the "How To" Cards which provide information about specific skills, such as making electric circuits that stay together. If many students, or even the entire class, need help in particular areas, the teacher should conduct skill sessions as these needs arise. (Background Papers provide teachers with additional information on general topics applicable to most challenges, such as analyzing graphed data, and on specific problems associated with this challenge, such as electric circuits.)

USMES teachers can also assist students by making it possible for them to carry out tasks involving hands-on activities. If the children need to collect data or to observe security methods outside of their classroom or

school--in a shopping mall or at the police station--the teacher can help with scheduling and supervision.

> *One fourth/fifth/sixth-grade teacher made arrangements for her class to visit a nearby shopping center to examine stores' security methods. Two adult volunteers assisted the teacher. At the center, the class broke into three groups (one adult per group), each group visiting different stores.*

If the children's tasks require them to design and construct items, the teacher should make sure that they have access to a Design Lab. Any collection of tools and materials kept in a central location (in part of the classroom, on a portable cart, or in a separate room) can be called a Design Lab. To carry out construction activities in a school without a full Design Lab, students may scrounge or borrow tools and supplies from parents, local businesses, or other members of the community.

> *After working two months in the school's Design Lab on unit activities, one third-grade class moved back to the classroom to work. During the time in the lab it soon became evident to the teacher that her class was unable to work efficiently in the lab due to scheduling and staffing problems and distractions created by children from other classes also working in the lab. Some rearrangement of the classroom was necessary in order to create work and storage areas. Design Lab tools were borrowed when needed, and many children brought in scrap materials from home. During the spring small groups returned to the lab with a teacher aide. It was generally felt by the teacher that the classroom arrangement was quite satisfactory. Unit activities were not confined to Design Lab scheduling and many children chose to work on their alarms rather than play a game during free time.*

Valuable as it is, a Design Lab is not necessary to begin work on a Protecting Property challenge. The lab is used only when needed, and this need may not arise during early work on the challenge.

Before using the school's Design Lab one fifth-grade class spent several weeks planning ways to secure their property. Designs for lockers and safes were drawn to scale. The cost of construction for each design was estimated, and the class discussed ways to raise money for supplies and materials when the Design Lab supplies ran out.

Culminating Activities

Student investigations generally continue until the children have agreed upon and implemented some solution to their problem. For example, they may construct containers with latches to secure their property or burglar alarms to protect the items kept in their lockers, desks, or the Design Lab.

One fifth-grade class built lockers, safes, burglar alarms, and Plexiglas lids to secure their personal belongings in the classroom. After these security methods were put into use, the class noted that personal items were no longer missing. They attributed this situation to their security methods and to the fact that they were more careful with their belongings.

3. USE OF PROTECTING PROPERTY IN THE PRIMARY GRADES

Children in the primary grades may make significant progress with the Protecting Property challenge of finding a good way to protect their belongings. Although their investigations may not be as sophisticated as those conducted by older students, they will be able to propose feasible solutions and take effective action on their challenge.

Discovering things missing from one's desk or locker is distressing to childern and makes the Protecting Property challenge real and highly motivating. When such an incident occurs, young children will eagerly offer their own experiences with missing things and will list possible ways to protect their belongings. In evaluating the suggestions for security methods, the children may eliminate some as being unsafe or unrealistic. The class may then choose the security items that they wish to make, such as security containers, burglar alarms, or lids.

The Protecting Property challenge was introduced to one second-grade class after money was missing from the teacher's purse. The class was concerned and wanted to do something to protect their belongings, particularly their desk belongings. They made a list of ways to secure their desks, which included the following ideas:

- *Make a door for the desk.*
- *Put things in a box and put the box inside the desk.*
- *Put a lot of bells around the desk.*
- *Get a locker or a suitcase.*
- *Buy a lock for the desk.*

For primary children, working with electrical components--batteries, bulbs, wire, buzzers, bells--is fascinating and challenging. In many classes the children spend many sessions trying different circuit and alarm arrangements. Their activities usually include dealing with open and closed circuits, series and parallel circuits, conductors and insulators, switches, and circuit drawing. In addition to providing for the practice of manipulative skills, these investigations also provide opportunities for the children to practice their reasoning powers.

Third-graders in one class experimented with different electric components and circuit arrangements. Although the children were not familiar with electrical components, they were quick to put together working circuits and to perceive differences in bulb brightnesses because of the different circuit arrangements (series and parallel circuits).

In trials of the Protecting Property challenge* young children show amazing persistence in searching for a workable alarm. In many cases the children design and build alarms that are quite sophisticated.

One third-grade girl constructed a window alarm that used a clothespin for a switch. A thumbtack was placed inside each clothespin jaw. Attached to each thumbtack were wires leading to a bell and a battery. When the clothespin jaws

*Formerly the Burglar Alarm Design unit

were together, thumbtacks touching, the circuit was complete. The clothespin was taped to the window sill. Separating the clothespin jaws was a piece of paper that was attached to a string. The other end of the string was tied to the window latch. The girl was careful to tape the string to the inside of a wooden crosspiece on the window frame so that the burglar could not see the string from outside of the window. When the window was opened, the paper was pulled from between the clothespin jaws, completing the circuit, and sounding the alarm.

Various aspects of measurement--units of measure, different measuring tools, and measurement reliability and accuracy--will arise as the children build their security containers or try to determine where their completed containers may be placed in the classroom. They quickly note that some sort of a unit of measurement is necessary when they discover that visual approximations or measurements using different units are difficult to compare.

To build the containers, the children use the necessary tools and materials. Experience in many schools has shown that small children are able to use saber saws with adult supervision and are able to learn the proper ways to use hand tools and other Design Lab materials. Working on other USMES challenges, primary children have constructed Tri-Wall tables, bookshelves, and a puppet theater.

Although the children work in small groups or individually on their security methods, they exchange ideas freely and help one another. Such an exchange also occurs during class discussions when designs are demonstrated and explained. This sharing experience not only provides an opportunity to exchange ideas but also allows for the practice of oral and listening skills.

Most primary children will remain interested and spend great amounts of time completing investigations that they consider important and relevant for some sort of resolution of a real problem.

4. FLOW CHART

The following flow chart presents some of the student activities--discussions, observations, calculations, constructions--that may occur during work on a Protecting Property challenge. Because each class will choose its own approach to the challenge, the sequences of events given here represent only a few of the many possible variations. Furthermore, no one class is expected to undertake all the activities listed.

The flow chart is not a lesson plan and should not be used as one. Instead, it illustrates how comprehensive investigations evolve from the students' discussion of a Protecting Property problem.

Challenge: *Find a good way to protect your ____________ (property in desks or lockers, bikes, tools, animals, etc.).*

Optional Preliminary Activities:

Other USMES units:
- *Bicycle Transportation*
- *Weather Predictions* ✓
- *Classroom Management*
- *Design Lab Design*
- *School Zoo*
- *Classroom Design*
- *Growing Plants*

Social science unit on community protection

Science unit on electricity and/or electromagnets

Possible Student Activities:

Class Discussion: What are some of the problems of keeping personal things in the classroom or at school, such as pens and notebooks, pets, bicycles? How can we prevent our personal things and classroom and Design Lab materials from being taken? Decision made on which problems are most urgent.

Data Collection: Observation of security methods used by stores, schools, and other public places.

Initial drawing of possible alarm systems.

Initial drawing of possible security containers.

Class Discussion: Reports of groups. Description of security methods used by stores and of alarm systems and containers designed by students. Consideration of the good and bad aspects of each security method. Formation of groups to construct or develop a security method.

Revision of drawings.

Investigation of electric circuits.

Construction of simple electric alarm systems, e.g., alarm goes off when desk or door is opened.

Construction of security containers, e.g., lockers, safes.

Investigation of the possibility of students organizing a schedule of random checks of the affected area, e.g., Design Lab.

Development of advertising campaign to publicize the fact that security devices or methods are in operation.

Class Discussion: Reports from groups. Students critique alarm systems, containers, and other security methods. Discussion of ways to improve each method. Consideration of the cost and effectiveness of each security method. Discussion of ways to measure effectiveness of each security method.

Improvements made on containers and locks.

Improvements made on alarm systems. Construction of more complicated alarms, e.g., incorporating an electromagnet.

Improvements made in schedule for random checks or in advertising campaign.

Trial of security methods that do not need to be changed.

<u>Data Collection</u>: Class or school survey to determine effectiveness of each security method.

<u>Data Collection</u>: Observation of classroom or affected area to see if thefts or destructiveness have been reduced.

<u>Data Representation</u>: Compiling survey results, observation notes. Analysis and interpretation of data. Preparation of bar graphs.

<u>Class Discussion</u>: Report of groups and discussion of evaluation results. Decision made on the effectiveness of each security method.

Consideration of other areas that need protection.

Further revisions made on security methods.

Continued use of alarm systems, security containers, or other security methods.

Optional Follow-Up Activities:

Other USMES units:
- *Design Lab Design*
- *Classroom Management*
- *Bicycle Transportation*
- *Mass Communications*
- *Classroom Design*
- *Advertising*
- *Consumer Research*
- *School Rules*

Science unit on electricity and/or electromagnets.

Social science unit on community protection.

5. A COMPOSITE LOG*

This hypothetical account of a fifth-grade class describes many of the activities and discussions mentioned in the flow chart. The composite log shows only one of the many progressions of events that might develop as a class investigates the Protecting Property challenge. Documented events from actual classes are italicized and set apart from the text.

Over the course of several weeks various children complain to the teacher that personal items are missing from their desks, including paperback books, pens and pencils, erasers, and small note pads. In a few cases the items were simply misplaced, but in other cases, the items are not in the classroom.

Today, the class returns to their homeroom from math class and begins to organize into their small groups to continue work on projects they have started. Because one group needs to use the classroom tools, they gather in the workbench area. As they prepare to work, one girl notes that the hammer and two screwdrivers are missing from the peg-board that holds the tools. The group is distressed because they need the hammer.

The group reports the three missing tools to the teacher, who immediately asks everyone to check their desks, to look behind the bookcases, and to look under the classroom furniture. A thorough check of the room reveals nothing. Now the whole class becomes concerned because they had spent a lot of time at the beginning of school scrounging for these tools. The students decide that they are too upset to continue work on their projects today. Instead, they decide to talk further on this problem.

A Protecting Property challenge arose in a Design Lab in Boston, Massachusetts, several weeks after school began. Materials were being taken from the lab when the Design Lab manager was out of the room. A group of fourth-grade boys was challenged to make an alarm to protect the Design Lab when the manager was out of the lab. (See log by Charles Donahoe.)

Members of one fourth/fifth/sixth-grade class in Lansing, Michigan, who loved fish, had a can with a slot in it for contributions to purchase new fish for the aquarium. On a Monday morning $1.25 was missing from the can. The class was very upset. They discussed how shocking this loss was for the room and talked about how to prevent another theft. (From log by Kathryn McNenly.)

*Written by USMES staff

The students speculate as to when the tools were taken and who would have wanted them. During the course of this discussion several students comment that things from their desks have also been disappearing. These children proceed to tell what they lost. The teacher finds this an ideal time to introduce a Protecting Property class challenge, "How can we prevent further losses from our tool pegboard and desks?"

The discussion quickly focuses on ways to prevent further losses. "Let's booby-trap our desks, so that when someone opens a desk, something slaps his hand!"

"Why don't we post someone in the room all the time?"

"Let's get some security guard dogs!" The teacher reminds the students that although these are good ideas, they need to think of security methods that they can feasibly employ in the classroom. One girl suggests starting a list on the board and volunteers to do the writing.

Over the course of an hour the class suggests and discusses the following ideas:

- Have someone from the class remain in the room at all times. (Someone else could bring back his assignments from other classes.)
- Put all personal things in a locker or a safe.
- Make book bags and carry everything around.
- Put the tools in a locker or safe.
- Put burglar alarms on the desks.
- Write names on everything with permanent ink.
- Change the school system--rather than having the students switch classes, have the teachers move from homeroom to homeroom.

After talking about each suggestion, several are eliminated because they are seen as unfeasible and/or very inconvenient. For example, although several students say they would not mind staying in the classroom during language arts, math, and science classes, they would mind during gym, recess, and lunchtime. Someone else comments that their parents would probably get pretty mad if they knew that their child was not attending classes. No one is keen on the suggestion to carry everything with them, particularly those children who have a tendency to fill their desks. The problem with marking everything is that someone can easily use permanent ink to scratch out the owner's name. Finally, the suggestion to alter the school system of changing rooms is seen as being unfeasible because "most teachers probably

would not want to move around from class to class." The teacher comments that the system was set up not because teachers do not want to move, but because it is too difficult to move all his/her materials around. Some teachers would have to have a large cart.

The class notes that two of their suggestions remain on the list: lockers or safes and burglar alarms. One boy comments that it will be a big nuisance having the tools in a container. Another boy wonders whether they can leave the tools hanging and build a container around the pegboard, something like a cupboard. Three other boys quickly voice their approval of this type of design, and ask if they can form a group to make such a container.

The teacher agrees, but asks what they will do about their desk belongings. One girl suggests that another group can design, construct, and install desk alarms for them. Another girl proposes that those working on the tool cupboard share lockers and have someone else make them. The boys agree to both ideas and agree first to decide which security method they want. The rest of the class then chooses whether to make a locker or a safe to put their desk belongings in or to design and construct a desk alarm. The class then breaks into these three groups--lockers group, burglar alarm group, and the pegboard cupboard group.

The fourth-grade boys in Boston designed a floor alarm so that when someone stepped inside the Design Lab door onto a Tri-Wall doormat, two metal pieces underneath the Tri-Wall piece came in contact with each other. This contact completed the electric circuit, making a light go on in their classroom across the hall. Upon seeing the light, someone immediately checked to see who was entering the room. (See log by Charles Donahoe.)

Fifth-graders in one class in Boulder, Colorado, faced the problem of protecting their personal belongings. A long list of ways to protect their items was made. Final means of protection were voted on and included making burglar alarms, lockers and safes, and lids for their tote trays. (See log by Laura Lyon.)

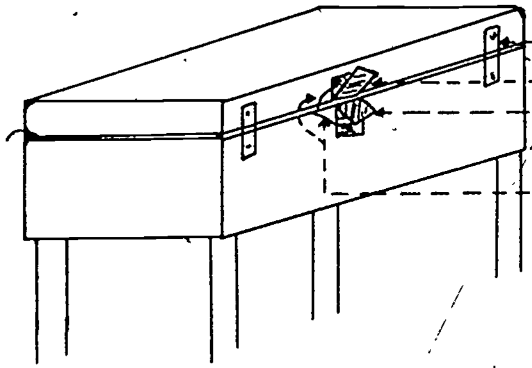
Alarm Group

Ideas for possible alarm designs are brainstormed. The discussion is difficult because some members cannot accurately relate their ideas. The group decides that each person should make a sketch of his/her idea and be ready to explain it to the group later.

Some of the group members design mechanical-type booby traps. One design uses a can and marbles. The can with marbles in it is taped to the inside of the desk top. When the lid is raised the marbles roll out of the can making a racket as they go.

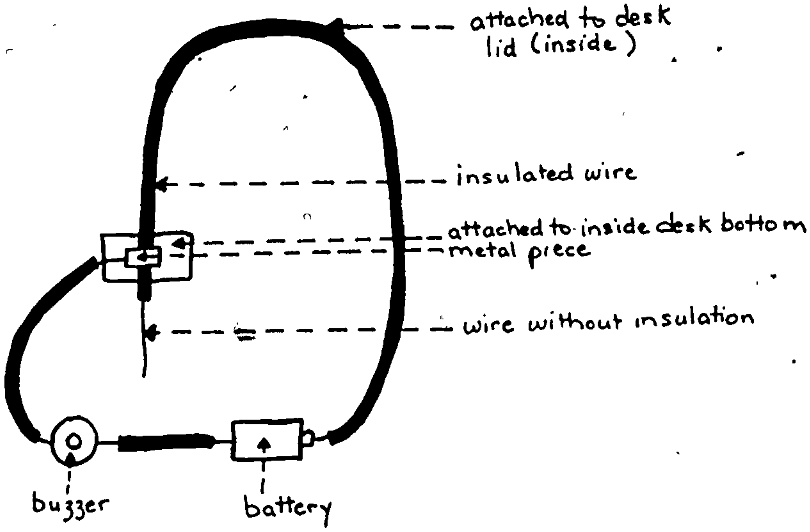
Some students want to make an electric alarm, and they experiment with buzzers, bulbs, batteries, and wire they have found. Although some students have no trouble in making a buzzer ring or a bulb light, others consult the "How To" Cards on circuits, such as, "How To Make a Simple Circuit" and "How To Make a Circuit Stay Together."

One girl designs an alarm so that when the desk top is opened, the circuit is broken, and the light bulb goes off. One boy who is somewhat knowledgeable in electric circuits uses the "How To" Cards--"How To Add Things to a Circuit" and "How To Make and Use Switches"--to design his alarm. His design is such that when the desk lid is raised, a metal strip tacked to the back of the desk lid touches a metal strip that is tacked to the desk bottom, completing the circuit and making a buzzer sound.



When everyone has completed his drawing, the group reconvenes. Each member shares his idea with the group, and the group then critiques each design. Several mechanical alarms are eliminated because their main problem is that everytime they are set off, it takes a long time to reset them. The design in which the bulb goes off when the lid is opened is also eliminated because they realize that the battery would wear out quickly. Everyone likes the design with the metal strips at the back of the desk, and so this one is submitted for the class to discuss.

The Alarm Group explains to the rest of the class the reasons that they rejected various designs. They then show the design with the strips, carefully explaining that when the two metal strips touch, a complete circuit is made. One boy points out a disadvantage of this design, that the metal strips are visible and can be easily bent out of shape so that they would not make contact when the desk lid is opened. Someone looks at the way the desk top opens and comments that the strips cannot be concealed inside.. Suddenly one boy thinks of a switch that can be placed inside the desk. He proceeds to draw and explain his idea.



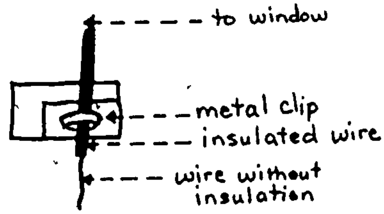
One end of a long piece of insulated wire is connected to the battery. The wire then extends to the desk lid where part of it is taped to the inside of the lid. The insulation is removed from the other end of the wire, and the wire passes through a metal piece that is attached to the inside of the desk bottom. Attached to one end of the metal piece is a wire that leads to the buzzer. As long as the insulated

portion of the wire is touching the metal piece, the circuit is not complete. Raising the desk lid draws the piece of wire up until the portion of the wire without insulation eventually touches the metal strip, completes the circuit, and makes the alarm go off. The class thinks this idea is clever, and the Alarm Group agrees to test it out.

The alarm is constructed and tested the following day. The group notes that the buzzer does not buzz every time the desk lid is opened. When it does buzz, the sound is not constant. They realize that how much noise the buzzer makes depends on the amount of contact the thin, bare wire makes with the metal piece. All agree that this is not a dependable set up.

One boy notes a further disadvantage to this design. In order to complete the circuit the desk lid must be raised high enough to bring the uninsulated wire in contact with the metal piece. The children agree that if anyone is going to take something from a desk, he or she certainly would not raise the lid that much. The wire is shortened but then they find it difficult to make any type of adjustment to alarm parts in the desk. They become exasperated and go to the teacher for ideas.

One sixth-grade girl in Champaign, Illinois, made a window alarm using a metal clip and an uninsulated portion of wire. The alarm was set up such that when the window was opened, the window pulled on a wire until the bare part touched the metal clip.



Two problems were discovered with this type of switch. If the window was opened quickly and wide, the wire was pulled out of the clip altogether, breaking the circuit. She also discovered that the metal clip gripped the insulated wire so tightly that another part of the circuit was broken before the wire would slide. (From log by Thacher Robinson.)

The teacher listens to the Alarm Group's problem and notes that they need to think of a system that can be set from outside the desk. She also notes that they seem to need a more reliable switch. She refers them to the box of odds and ends on the workbench and suggests that they may find something for a switch in the box. She also reminds them of the "How To" Cards on switches.

Scrounging through the odds-and-ends box, the group finds a clothespin, which two boys excitedly decide can replace the wire and metal piece switch. Two thumbtacks are stuck to the inside of each clothespin jaw. The wire from the battery is then soldered to one of the thumbtacks and the wire from the buzzer is soldered to the other so that a complete circuit is made when the jaws are together. If a piece of cardboard is placed between the jaws, the circuit is broken.

The group tapes the clothespin inside the front part of the desk. One end of a long piece of cardboard is taped to the desk lid; the other end is clasped by the clothespin. When the lid is opened, the cardboard piece is yanked from between the clothespin jaws. The group notes that the buzzer sounds every time the cardboard is removed. One boy points out, however, that their alarm arrangement again requires that the lid be opened quite far before there is enough tension on the cardboard for it to be pulled from between the clothespin jaws. The group groans.

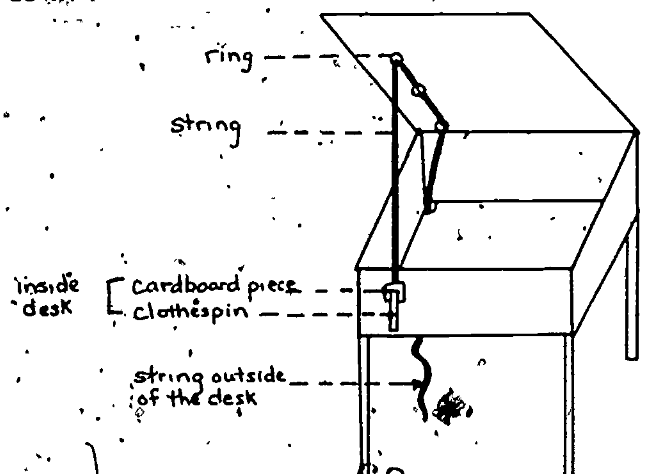
While the rest of the group sits around deciding what to do next, one boy closely examines a desk. He notices small spaces around the area where the desk legs pass through the bottom of the desk. As an experiment he drops a long piece of twine through one of these spaces so that one end of the string is inside of the desk and the other end is hanging down outside the desk. By this time several of the group members are drawn to what he is doing. When they see the arrangement of the string, they excitedly propose tying one end of the cardboard piece to the string. When this is done, the desk lid is shut. Someone pulls the end of the string that is outside of the desk. The string becomes taut and pulls the cardboard from between the jaws.

The group suddenly becomes excited. They quickly reset the clothespin switch and shut the desk lid. Before they can pull the string on the outside of the desk, someone accidently begins to open the lid. As the lid is raised, one observant boy notes that the string is drawn through the space into the desk. He quickly grabs the string and tells

someone to open the desk lid again. The desk lid is opened slightly and the string becomes taut. Suddenly there is a snap, and the buzzer sounds.

A group of boys in the fifth-grade class in Boulder devised an alarm using a clothespin as a switch. Metal pieces were glued to the inside of each clothespin jaw, and wires connecting the buzzer and battery were taped to the metal pieces. The clothespin was attached to the tote tray, and the cardboard insulator was taped to the back of the tote tray rack. When the tray was pulled out, the insulator was yanked from between the clothespin jaws, completing the circuit and setting off the alarm. (See log by Laura Lyon.)

For the next several days the group works on their alarm design. The clothespin is glued inside the desk front because the tape eventually wears out. To prevent the contents of the desk from interfering with the string, three rings are glued to the desk lid. The string then passes through these rings to the back of the desk, through a space next to the desk leg, and out the bottom of the desk. The string is long enough so that the lid can be opened wide without having the string be drawn completely into the desk. The cardboard piece is replaced with a small leather piece because the cardboard ripped after several tugs. When adjustments are completed inside the desk, the string outside the desk is pulled taut and taped to the underside of the desk.



A third-grade boy in Lansing, Michigan, designed a desk alarm that could be reset outside the desk. The alarm components (battery and buzzer) were taped to the underside of his desk. A piece of cardboard was inserted on the buzzer so that an incomplete circuit resulted. The cardboard was attached to a length of string that wound around a pulley, went through a hole in the desk and was taped to the inside of the desk lid.. When the desk lid was raised, the string pulled the cardboard piece from the buzzer, making a complete circuit. (From log by Lucy Knappen.)

During the next class discussion the Alarm Group demonstrates their alarm. The alarm is set, and when someone raises the lid a tiny bit, the leather piece is pulled from between the clothespin jaws, and the buzzer sounds. Everyone is amazed.

Someone then notes that in order to stop the buzzer from working, the group must yank a wire off the battery. He suggests putting an on-off switch on the desk bottom. Some agree that this is a good idea. Others say that they would rather loosen the string to get into the desk and tighten it when they leave. Since no one can think of any further improvements, the Alarm Group asks who wishes to have such an alarm installed in their desks and how they want to turn it on and off and indicate whether they want a switch or not.

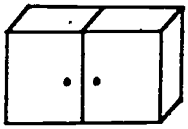
At this point in the discussion someone wonders if they should warn others that alarms are in operation. She cites several examples of seeing burglar alarm or watchdog warning signs in public buildings. The class thinks this idea is good because the signs would further intimidate would-be thieves. Part of the Alarm Group decides to make the signs, while the other members choose to make and install their alarm design into the various desks.

Pegboard Cupboard Group

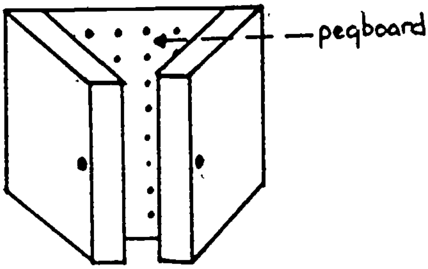
The group brainstorms ideas for the cupboard. The boy who had suggested making the cupboard during the class discussion elaborates on his idea. He explains that they need to measure the pegboard and then to build a cupboard large enough to enclose the pegboard. He suggests using plywood for the cupboard. One boy who is familiar with carpentry claims that if plywood is used, the cupboard will be heavy. He wonders if they are capable of making a strong enough support on the wall for the cupboard and the tools. Someone

then suggests using Tri-Wall. The group decides to compare both materials when they go to the supply room where some building materials are stored.

The boys next discuss the cupboard design itself. The design they agree on is rectangular in shape with two doors.



One boy wonders why the pegboard itself cannot serve as the back of the cupboard; they would then need to build only five sides (one front and four sides). No one can think of a reason against this idea, and so they agree to do this. One boy proceeds to redraw their design on the board, and it appears as follows.

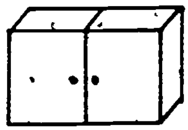


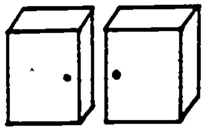
In the supply room the group compares the weights of plywood and Tri-Wall. Someone picks up a medium-sized piece of quarter-inch plywood and exclaims how heavy it is. Other members lift the piece and agree. A larger piece of Tri-Wall is then picked up by all, and the decision is unanimous--they decide to use the Tri-Wall. The group then returns to the classroom to take measurements and to draw the final plans.

When the plans are complete, the boys begin construction. Two boys measure and mark the cupboard pieces on the Tri-Wall. The boys take turns using the saber saw to cut the pieces. Three boys then use the hot glue gun to glue the Tri-Wall pieces together.

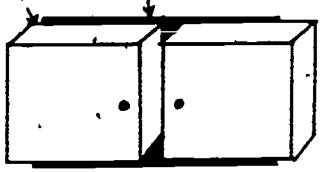
When the three-dimensional cupboard doors are finished, someone removes the pegboard from the wall. The doors are placed on top of the pegboard, and someone tries to open them. The doors open only slightly because they are placed

too close to each other and their thickness interferes with their opening. The problem is brought to the class and someone suggests that the doors be pushed apart until they open wide easily.





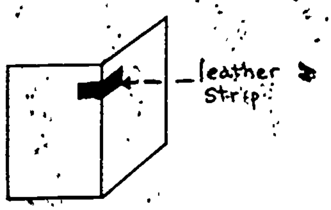
One observant member of the group points out that when the two doors are pushed apart, they extend slightly beyond the pegboard.



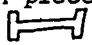
The group realizes that each door must be trimmed to lie flush with the pegboard. At first they decide to ignore the overlap problem, but then someone suggests that they may have difficulty attaching hinges. Two boys volunteer to remove the two affected sides, trim the door fronts, and reglue the sides.

While these two boys are making the necessary adjustments, one boy investigates kinds of hinges that will secure two pieces of Tri-Wall. As an experiment he connects two pieces of Tri-Wall with a metal hinge and regular screws. The hold is only temporary. After opening and shutting the two Tri-Wall pieces five times, the screws become loose. On the seventh opening one screw falls out of its hole. Realizing that this method is inadequate, he scrounges around in the odds-and-ends box and finds some leather scraps. He cuts one piece into a rectangular shape and glues one end of the

leather strip to one piece of Tri-Wall, the other end to another piece.

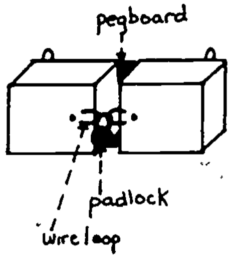


After opening and shutting the two pieces ten times, the leather piece is still secure. He excitedly shows this to the rest of the group, who agrees to adopt his hinge until one boy asks whether the leather will stick to the pegboard. The boy hesitates, and everyone agrees that this should be tested.

Students in the Boulder class made Tri-Wall hinges for their lockers. A piece of Tri-Wall was cut in the following shape:  *. One end of the Tri-Wall piece was glued to the locker side. The other end was glued to the door. The center part of the hinge was wrapped with masking tape to allow for flexibility. (See log by Laura Lyon.)*

Students in one second-grade class in Ganado, Arizona, made doors for their desks to protect their personal belongings. To attach the Tri-Wall door to the desk, they used tape. Although the tape allowed for flexibility, it had to be replaced frequently. (From log by Celia Rencher.)

Because the metal hinges did not secure well to the Tri-Wall, the group designs their own latch to secure the locker door. A piece of clothes hanger wire is bent into a horseshoe shape. The two ends of the wire are then stuck through the Tri-Wall door near the opening edge. Inside the door, the wire ends are bent so that they intertwine. A horseshoe-shaped wire is attached to the other door in the same way. Someone brings a padlock from home. The padlock is placed through the two metal loops and locked.



The glue and leather strip test on the pegboard shows the joint to be quite secure. As a precaution, however, clothes hanger wire is installed in the same manner as in the latch, through the pegboard and leather pieces and intertwined on the inside.

Finally, two members paint the cupboard. The cupboard is hung on the wall, and the class marvels at it. Someone asks who will be in charge of the cupboard key, and everyone agrees that the teacher should be.

Lockers Group

Before the children draw plans for their lockers they decide what things they wish to store in them. Some children want to store only their desk belongings; others wish to store their lunches and coats in addition to their desk belongings. They estimate the amount of space required for the items and base the locker dimensions on these estimations.

When their plans are complete, the children go to the supply room to get quarter-inch plywood or Tri-Wall, whichever they choose to work with. The material is brought to the classroom where the locker pieces are measured and marked. Children then take turns using the saber-saw to cut the Tri-Wall or plywood.

Inaccuracies in measurement and/or cutting become evident when the children assemble the lockers. Two girls, who have glued three sides of their Tri-Wall locker together with a hot glue gun, discover that the fourth side is much shorter than the other sides. Before they can cut a new piece, someone suggests gluing an extra piece to the short side to extend it. Two other lockers also require several small pieces of Tri-Wall to patch crevices where sides do not exactly meet.

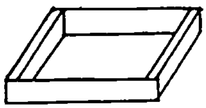
One group of boys in the Boulder class discovered that the wood piece they had cut for the safe roof was five inches short, leaving a five-inch gap. At

first they decided to cut all the sides down to match this smaller piece but then changed their minds. Instead, they designated this gap as a doorway. (See log by Laura Lyon.)

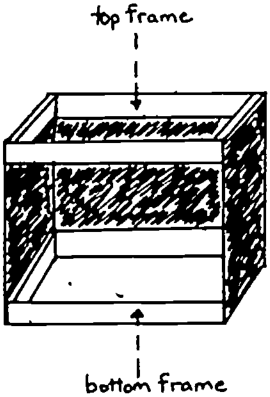
Children working with the quarter-inch plywood face the problem of how to nail two pieces together at a right angle. Everytime they drive a nail into the edge of the plywood, it splits. They are about to give up when they remember a cupboard in another classroom that had been built to hold a teacher's excess materials. They decide to examine how this cupboard is built. Obtaining permission from the teacher, they go to the other classroom.

The teacher's cupboard is made of quarter-inch plywood. They notice that thicker wood (two-by-four pieces) is used to form a frame to which the thinner wood is nailed. They decide that they, too, need to make a frame from thicker pieces of wood and return to the supply room. They obtain several pieces of three-quarter-inch wood that is two inches wide.

The children use the thicker wood to build their frames by nailing four rectangular pieces together.



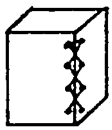
Two frames are made to support the locker sides, one at the top and one at the bottom.



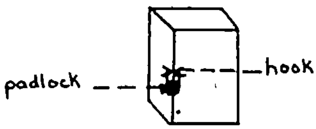
One group in the Boulder class used three-quarter-inch blocks of wood to support their locker sides. Four short pieces were nailed to the floor of the safe. The sides of the safe were then nailed to these pieces. Three-quarter-inch pieces were also nailed to the tops of the safe's sides. The safe roof was then nailed to these pieces. (See log by Laura Lyon.)

The students who make their lockers with the plywood use the metal latches and hinges in the odds-and-ends box to secure the locker doors. Those whose lockers are made from Tri-Wall decide to make their own latches and hinges after they learn about the Pegboard Cupboard Group's experiment with the metal hinges. Several students copy the Pegboard Cupboard Group's leather hinge and clothes hanger loop latch. Other students create their own.

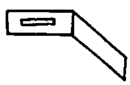
One boy attaches his locker door with a rope hinge. Holes are made along the locker side and along one side of the door. The rope is then laced through the holes, and the ends are tied together inside the locker.



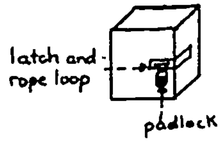
For a latch the boy also uses rope. A rope loop is made on the door and on one side of the locker. The ends of the loops are tied together inside the locker. The two loops are then padlocked together.



One girl makes a latch with Tri-Wall. For the clasp she cuts a long rectangular piece, bends it in the middle and cuts a slit in one of the halves.



The half without the slit is glued to the locker side. The slit half of the clasp is slipped over a rope loop that is secured to the locker door with a knot inside the locker, and a padlock is placed through the rope loop.



Girls in the Boulder class made a latch using wire and Tri-Wall. A rectangular piece of Tri-Wall was cut and folded in half, and a slit was made in one of the halves. The unslit half was glued to the locker side. For the lock ring, they bent a strong piece of wire into a horseshoe shape. The two ends of wire were stuck through the door. The ends were then bent and taped to the inside of the locker. To latch the door, the slit part of the Tri-Wall piece slipped over the metal ring. A padlock was then hooked through the metal ring and locked. (See log by Laura Lyon.)

One boy chooses to have a burglar alarm installed inside his locker. He gets the Alarm Group to install their clothespin alarm. A hole is drilled at the back of the locker for the string that is attached to the leather insulator. The clothespin switch is glued inside the door. When the boy wishes to get into his locker without setting off the alarm, he untapes the string at the back of the locker.

Decorations are painted or pasted onto the lockers before they are placed in free spaces in the classroom. Two girls post a warning sign on their locker door.

The three children who have been making the warning signs ask the rest of their classmates where to post them. Some children say to hang them anywhere they can be seen. Others feel that they should be strategically placed in order to make them look important and more threatening. Such strategic places are identified and include, on the wall next to the door, above the chalkboard in front of the classroom, near the classroom clock, and near the pencil sharpener and light switch. Some of the signs are reprinted because they

appear too much like a poster with a lot of color and fancy designs. The class feels that the signs should be simple and plain.

Over the course of several weeks the class notes that personal items from desks and lockers are no longer missing and that no tools are missing from the pegboard cupboard. They surmise that their means of protection are effective.

After their alarms were put into working order and the lockers and safes completed, the Boulder class noted that nothing further was missing nor taken from their tote trays and classroom. The class felt that their security methods were effective. They also agreed that everyone was more careful in putting away his or her belongings. (See log by Laura Lyon.)

During these weeks, however, another problem arises. Because the lockers were placed wherever there were free spaces, the room is more congested. In order to get to the reading corner, a child must squeeze between a desk and a locker. The workbench area has also been reduced. The problem is raised during a class discussion, and the students begin thinking of ways the classroom furniture can be rearranged. Later in the discussion the teacher introduces the Classroom Design challenge.

6. QUESTIONS TO STIMULATE FURTHER INVESTIGATION AND ANALYSIS

- What are some of the problems you have keeping your personal things in the classroom or at school?
- How can you prevent personal things or classroom and Design Lab materials from being taken?
- What security items are feasible for you to design and construct?
- How much will your item cost, approximately? How can you find out?
- How can you rig your desk (classroom door, window, etc.) so that it sets off some sort of a signal when it is opened?
  - How long will the batteries last?
  - What kind of a signal could be heard or seen easily?
  - What kind of a signal would be good to use for short distances? For long distances?
  - How should the alarm components be affixed to the desk (door, window, etc.) so that someone cannot see them?
  - How can you fix your alarm system so that it resets itself each time the desk (door, window, etc.) is closed?
  - How can the alarm system be turned off during the times when you want to get into and out of your desk?
  - How many times will your alarm work without being adjusted?
- What things do you wish to store in your container?
  - How big should you make it? How can you find out?
  - How can you build it so that it cannot be easily broken into?

- How can you make a latch and hinges that will secure your wooden container?...your Tri-Wall container?
- Where will you put your finished container?
- How can you be sure that it will fit in the area that you wish?

- What would be the best times to check the classroom (affected area)?
  - How often should the area be checked?
  - What is a good schedule for making random checks?
  - How can you remind others when it is their turn to check the area?
- What would be a good way to warn others that security methods are in effect?
- How effective is each security method? How can you find out?
- How does the effectiveness of a security method compare to its construction and operating costs?
- How can you improve your security method?

C. Documentation

1. LOG ON PROTECTING PROPERTY

by Stephen Hanson*
Monte Vista School, Grade 4
Monterey, California
(December 1971-May 1972)

ABSTRACT

This fourth-grade class worked twice a week designing and building alarms to prevent others from entering their classroom and taking equipment. The students made door, floor, desk, and window alarms. With some hints from the teacher, several students made window alarms that used electromagnets as switches. There was also an unsuccessful attempt to adapt the window alarm design to a geodesic dome covering their greenhouse.

The class experimented with electric components, such as batteries, bulbs, and wire, before we discussed possible ways to protect our classroom. The students tried different circuit arrangements and determined those that did and those that did not work, e.g., by lighting a bulb.

Following two days of experimentation we discussed ways to prevent others from entering our classroom and taking equipment. I challenged them to design a burglar alarm at a reasonable cost that would give effective warning.** One student suggested that we purchase an alarm system. Hands immediately went into the air with offers of financial assistance. One student offered ten dollars while another offered twenty. Before this line of thinking got too far, I asked them whether it was possible for them to build an alarm. After some thought, my idea seemed to make sense to them.

Several ideas were presented for possible alarms. One student suggested attaching a string to the classroom door in such a way that when the door was opened, a gun would go off. Another student suggested using a bow and arrow in place of the gun. We decided that these ideas were not feasible--"What would happen when the janitor came in?" The class then decided to draw their ideas of electrical alarms on paper.

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*Edited by USMES staff

**Formerly the Burglar Alarm challenge--ED.

The students' drawings were at first very crude and tended to show where the buzzer or bell would be located rather than how the system would be hooked up. They included details after I asked them how the alarm worked.

During the next session those who had done some serious thinking and had a detailed diagram of what they wished to build proceeded to the Design Lab to work. Others continued to make refinements to their drawings. The students were encouraged to work on simple circuits first before moving to more complicated ones.

Several students experienced difficulty making store-bought bells and buzzers sound. One group of boys tried several combinations of battery arrangements, but they failed to make a doorbell ring. They finally succeeded after connecting it to a large three-volt dry-cell battery. Several other students, in an attempt to get a buzzer to sound, also tried many combinations of battery arrangements with no positive results. They finally concluded that their buzzer was faulty.

One boy made a door alarm using four batteries, a piece of cardboard, and a bell. The cardboard piece was placed between two batteries to break the circuit. One end of a piece of string was attached to the cardboard; the other end was attached to the classroom door so that when the door was opened, the string became taut and pulled the cardboard piece from between the batteries (see Figure C1-1).

Another boy brought to class a floor alarm that he had constructed at home. The circuit included a battery hooked to a doorbell that was triggered by a doorbell switch. The whole system could be turned off or on with another switch. A person entering the room stepped on a board that pushed down the doorbell switch, sounding the doorbell. Figure C1-2 shows the diagram of his alarm.

When our USMES observer entered our room one day, she was treated to an unplanned surprise. As she stepped on the board near the doorway, the doorbell sounded, and everyone gave a big cheer for the successful alarm.

We decided that the alarms built so far were pretty good. We talked about ways the alarms could be improved ("Is a bell a good alarm?") and whether we were adequately protecting our classroom ("Is the burglar going to have a key to the classroom door or is he going to break a window to enter?").

The class became interested in building a window alarm when they realized that the windows were indeed places of entry. During after-school hours some of the children went

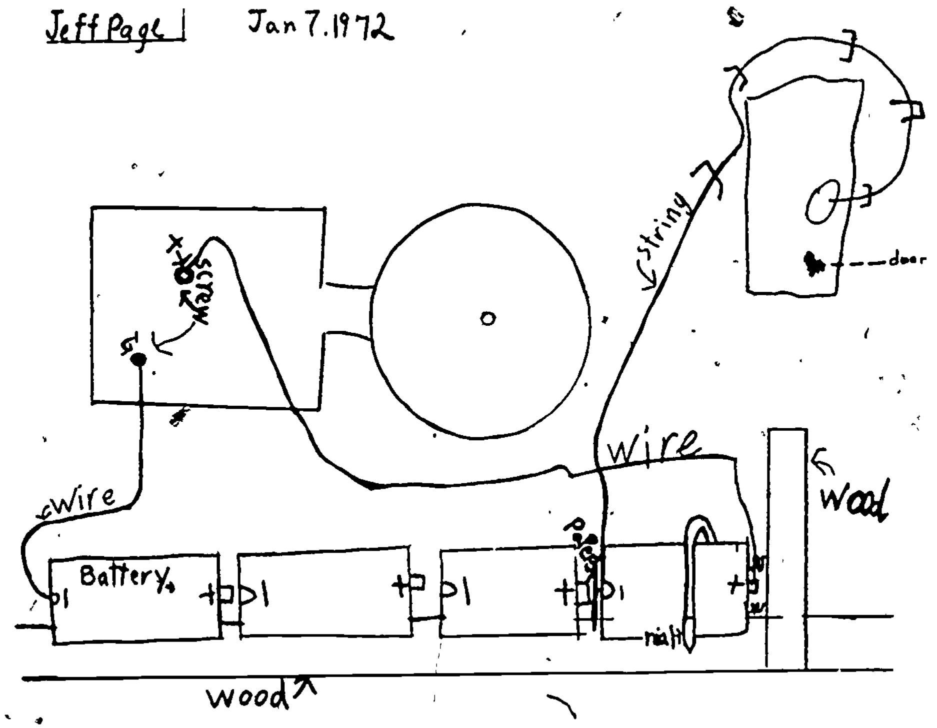


Figure C1-1

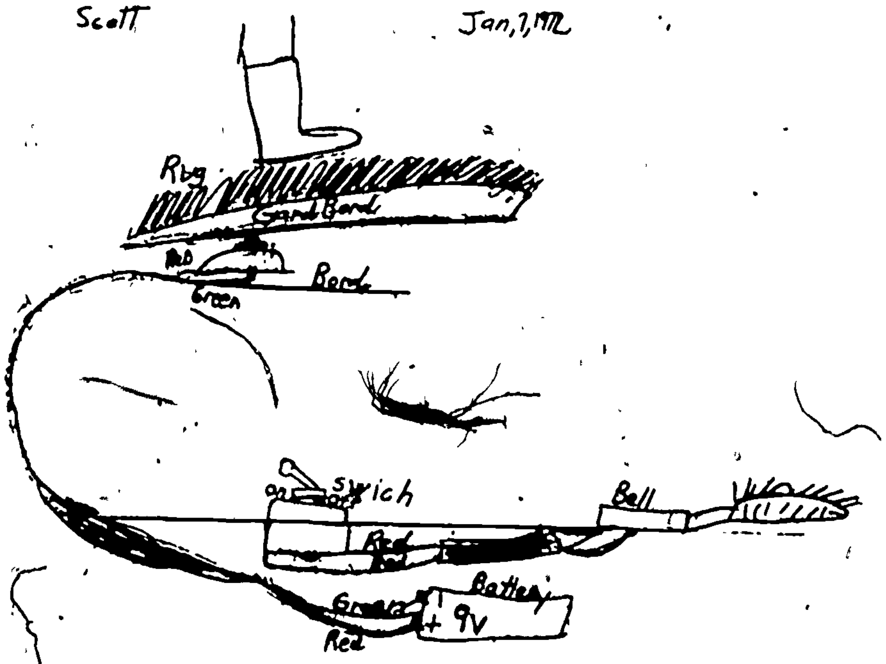


Figure C1-2

downtown to look at alarm systems. In several jewelry stores they noticed a tape around the windows. All they could figure out was that when the window was broken, the alarm went off because the tape was broken. No one could explain why the alarm sounded when the circuit was broken.

The class puzzled over the window alarm circuit and became frustrated because no ideas came to them. At this point I introduced them to electromagnets, briefly explaining what they were and how they worked. I asked them to experiment with them and to perhaps use their knowledge of electromagnets to build a window alarm.

The class was fascinated with the electromagnets they had made by wrapping insulated wire around nails. They experimented with them, such as varying the distance from the electromagnet to the battery (i.e., the length of the connecting wire) and noted the electromagnet's strength each time (e.g., number of paper clips it would pick up). Many students experimented with the number of coils of wire around the nail to see the effect on electromagnet strength. They found that the more turns of wire around the nail, the greater the magnetic force (as measured by the number of paper clips it picked up) up to a point; after that point the magnet was less effective.* The class also discovered that large dry-cell batteries lasted longer than the flashlight batteries.

Eventually, one boy thought of a window alarm design that used an electromagnet to close a circuit containing a bell. He drew his idea on the board (see Figure C1-3), and the class critiqued it. They raised several questions about the alarm:

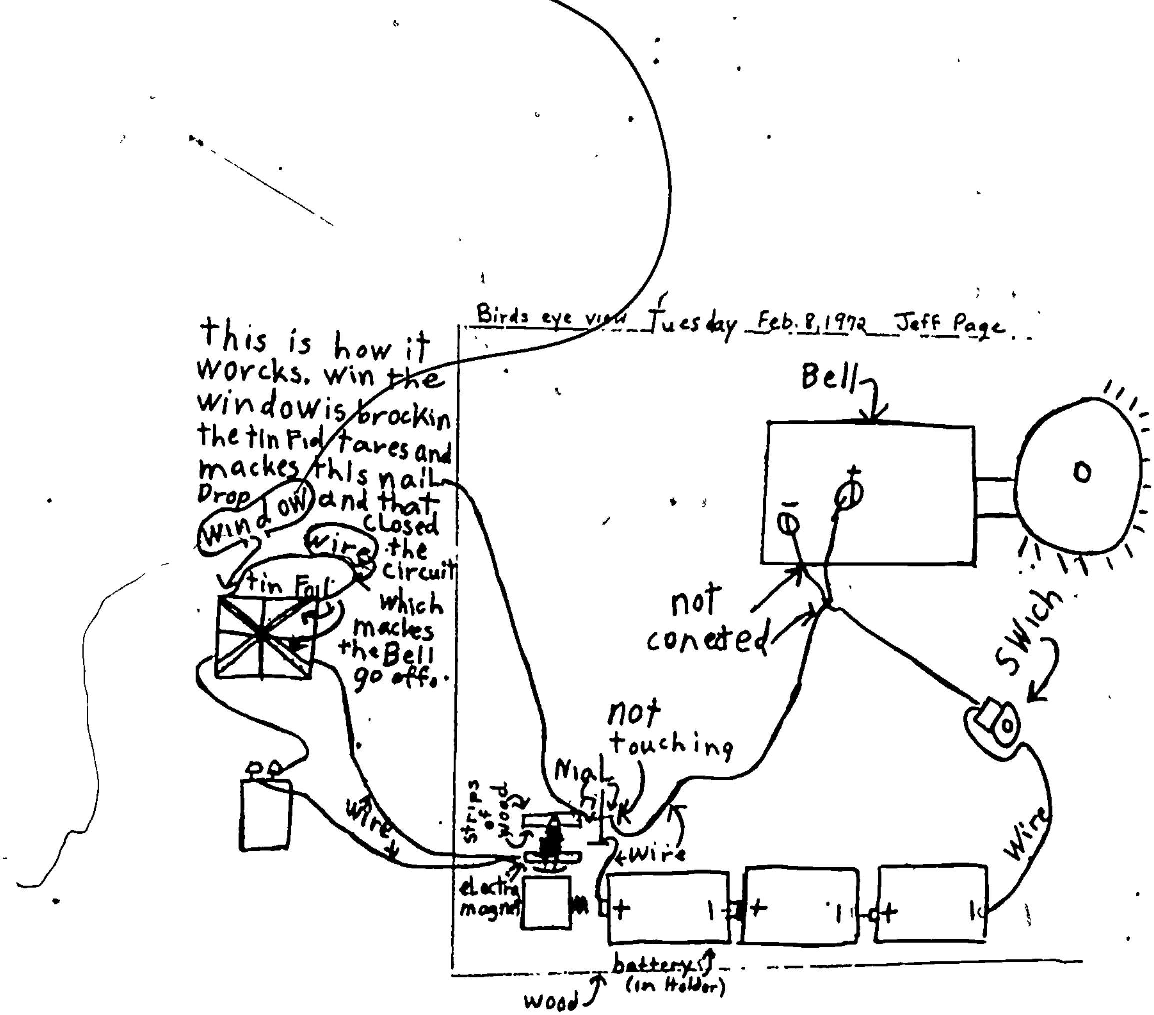
1. Can the burglar break the window without disturbing the electromagnet switch?

2. How long will the flashlight batteries operate?

3. How many batteries will you need to hold up the nail, thus keeping the circuit open?

4. Even when the alarm works, will the warning device be "effective"? Who will hear the bell?

*The children might draw a line graph of number of paper clips held up vs. number of turns of wire on the electromagnet.--ED.

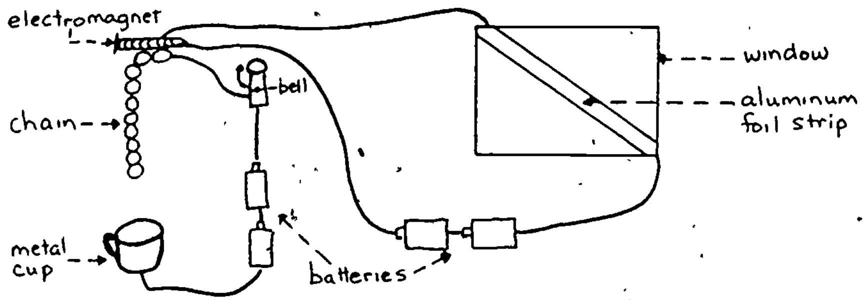


Birds eye view Tuesday Feb. 8, 1972 Jeff Page
this is how it worcks. win the window is brockin the tin Foil tares and mackes this nail Drop and that closed the circuit which mackes the Bell go off.
window
wire
tin Foil
Bell
not coneted
SWich
not touching
Nial
strips of wood
wire
Wire
electro magnet
Wire
battery (in Holder)
wood

Figure C1-3

The boy worked three days on his alarm, designing a crude relay to enable the alarm to go off when the window was broken. He finished the alarm on the fourth day, using tin foil across the window to complete the electromagnet circuit. When the foil was broken (i.e., the window was smashed), the electromagnet dropped a nail that subsequently made contact with a metal piece, thus completing the bell circuit. He tried it out in front of the entire class. It worked!

Another boy made a similar window alarm, but replaced the nail and the metal piece with a chain and a metal cup. When the window was broken (i.e., aluminum foil strip broken), the electromagnet released the chain. The chain, which was connected to a bell with a piece of wire, dropped into an aluminum cup that was connected to several batteries. This action completed the second circuit, making the bell sound.



Two girls accidently designed an alarm system based on a short circuit. The alarm bell would ring only when two metal pieces were separated. Although the alarm worked, they soon discovered that the short circuit quickly drained the batteries. To overcome this problem, they decided that a switch should be put in the short circuit wire. This switch would be closed only for a short period each day when it was important for the alarm to work, thereby conserving the batteries the rest of the day.

Several events that occurred in the school prompted the class to search for new types of alarms. The events included the following:

1. The art teacher had some materials taken from one of her cupboards. I asked the class whether they could design an alarm for her.

2. Several students had complained that their electrical supplies were missing from their desks. I suggested that they build a desk alarm.

3. The greenhouse had been broken into (the geodesic dome was broken). Plants were overturned and some were destroyed.

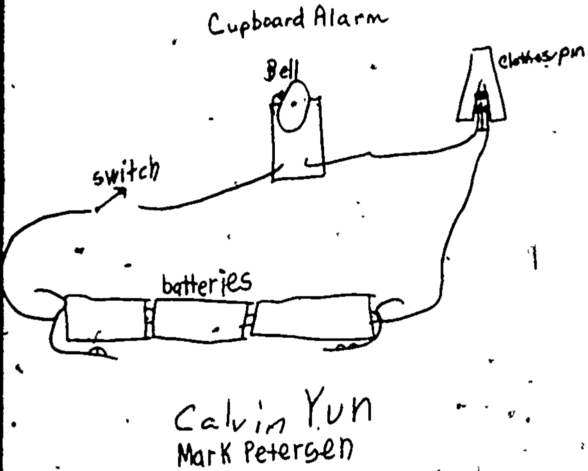


Figure C1-4

The class enthusiastically broke into groups, each one working on the problem that interested him/her.

We talked about possible designs for a drawer or cupboard alarm. Someone suggested using a clothespin for a switch by putting tacks inside each clothespin jaw and using a piece of cardboard or paper to insulate between these two contact points. Two boys proceeded to use this idea in their design of a cupboard alarm (see Figure C1-4) in which the opening of the cupboard door caused the insulator piece to be yanked from between the clothespin jaws, completing the circuit.

Students tackling the geodesic dome problem decided that the window alarm design with the electromagnet could be altered to protect the greenhouse. They suggested placing one big strip of aluminum foil around the inside of the dome. Several questions arose during their discussion.

1. How far is it around the dome on the inside?

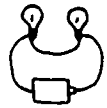
2. How much aluminum foil do we need?

3. Will the electromagnet work with so much foil between it and the battery?

The following day one boy connected a thirty-foot strip of aluminum foil to his electromagnet circuit. He discovered that both the one-and-one-half-volt dry-cell battery and the three-volt dry-cell battery did not send enough current through the thirty feet of foil to make the electromagnet work. Some students suggested adding more batteries to the circuit to generate more current. Other students wondered how long the current would last, even if they could make the circuit work. They guessed that a dry-cell battery would generate a current for as long as one week. Due to the shortage of dry-cell batteries, however, the class was unable to test this assumption.

Because the students seemed stymied with the problem of adapting their window alarm to the geodesic dome, I put two

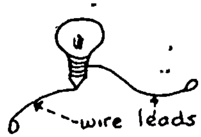
diagrams on the board and asked them what would happen to the lights in each of the two circuits. Some girls experimented and found circuit B lit both bulbs equally bright and twice as bright (approximately) as circuit A. I asked the class if there was any way to use this information to solve our problem with the geodesic dome.



The students pondered the geodesic dome problem for several days and eventually gave up in despair. They agreed that, in addition to the aluminum foil and electromagnet problem, there were many other places in the window alarm design that could cause trouble. They guessed that the number of breakdowns would increase considerably if they adapted the alarm design to the geodesic dome.*

While testing alarms, the students discovered that many alarms failed because of poorly connected wires, loose batteries, or broken switches. In many cases the batteries were attached to a piece of wood with wooden braces or with tape. To secure the batteries, battery holders were made from strips of tin. Wires were soldered.

A circuit tester was made to diagnose faulty circuits. Two wire leads were connected to a #41 light bulb. By touching various contact points with the wire leads, the students could determine places in the circuit where electricity was not getting through.



By spring many students' enthusiasm had waned. However, those who were still interested in the alarms continued to implement and repair them.

*Older students might investigate different materials and various circuits that would reduce the resistance of the foil circuit. They could also design a more sensitive electromagnet.--Ed.

2. LOG ON PROTECTING PROPERTY

by Laura Lyon*
Heatherwood School, Grade 5
Boulder, Colorado
(October 1975-February 1976)

ABSTRACT
After having several students report to her about missing personal items, this fifth-grade teacher decided to discuss the problem with her class. During the discussion it became evident to all that not only were items missing frequently but practically everyone was affected. The class identified four problems (ransacked tote trays, stolen lunch boxes, stolen lunches, and smashed lunches) in which protection seemed needed and then made a long list of ways to solve the problems. A vote was taken to decide which problem to tackle first and to choose a protection device or container on which to work. The students chose to make lockers, alarms, safes, and lids to cover the tote trays. For five weeks the class worked in the Design Lab. During this time the frequency of USMES sessions increased from one and a half times per week to three times per week. In order to place the finished lockers and safes in the classroom, some of the desks and tables were rearranged. The students were very satisfied with their ways of protecting their belongings.

Since the beginning of school several students had come to me to report personal items missing from their tote trays or lunch boxes. (The students at Heatherwood have tote trays in which to store their books, papers, and personal items. The trays are portable, but most students leave them in their homeroom when they attend classes in other areas of the building.) After one such report I decided to discuss these incidents with the class.

I opened the class discussion by telling them about my concern for the incidents of missing items. Apparently this was a very common experience because the students immediately began telling about all the personal items that had been lost, misplaced, or taken by someone. Missing items included such things as scissors, erasers, pencils, books, mittens, lunch boxes, food in the lunch boxes, and Chap-Stick tubes. Also brought out in the discussion was the

*Edited by USMES staff

fact that many times lunches were found smashed. We concluded that protection of personal property was a real problem, and we proceeded to discuss ways to resolve it.

A lively discussion ensued on possible ways to secure their property to avoid further misplacement or stealing. Suggestions included--

1. buy a safe
2. buy lockers
3. write your name on things with permanent ink
4. scrape paint off a pencil and write your name on it
5. put sticker tape on everything
6. take everything with you in a zipper bag
7. mark everything with paint
8. put locks on boxes
9. install burglar alarms
10. put your tote tray away
11. make a class can for glue, pencils, scissors, etc.
12. bring your lunch box in before lunch recess
13. bring your lunch in a sack rather than a box
14. have a guard in the room during recess
15. keep your tote tray in the tote tray rack all day.
16. get a lock for your lunch box

The first two suggestions prompted several to ask where we would get the money to buy them, and someone suggested holding a bake sale. No one liked the zipper bag idea because "Who wants to carry bags around all day?" The twelfth suggestion prompted me to remind them of the school rule that no one was allowed in the area during recess. They modified this suggestion by having one person count all the lunch boxes. If all were present, this one person would bring them all in.

We looked at the long list and decided that our protection problem concerned four things--tote trays, lunch boxes, and missing or smashed lunches. I asked them which problem they wished to tackle. Several students felt that the lunch boxes and the food were very important. But one girl objected because she wondered why someone would want a stolen lunch box. "What can you do with it but look at it at home?"

Two girls insisted that the food problem was important. One girl claimed that several times she had to buy a hot lunch because her lunch had been taken. Because the class

	Adv.	Dis.
Safe	1. people can't open it	1 it cost to much 2 were to keep it
lockers	1. people can't open em	1 it cost to much 2 were to put it
names in ink	1 cant rub off	1 nothing
sticker tape	1 has name on it	1 people can pull it off
zipper bags	1 you can have them with you	1 might forget it 2 people can still open it 3 were to keep
box locks	1 have them with you	1. heavey 2 people can still steal
paint	1 cant come off easy	1 none
alarm	1 you can tell when someone takes something	1 money
put things away	1 nothing	1 people can still steal
class can	1 people can't take things	1 none
share totray	1 more room	1 person can steal 2 still dosent help
board	1 none	1 he might steal
keep totrays in rack	1. none	1 can still steal
Briefcase	1 can have with you	1 were to keep
plastic lid	1 can't steal	1 None

Figure C2-1

was divided, one boy suggested that we vote. The four problems were listed on the board:

1. tote trays
2. smashed lunches
3. missing lunch boxes
4. missing food

The children then listed various ways to tackle one or all of the problems:

1. Get into groups, each group solving one problem.
2. Solve all the problems as a class one at a time.
3. Individuals or groups solve their own problems.

The class voted to solve all the problems one at a time as a class beginning with the tote tray problem.

We then returned to our original list of ways to secure our property. For each way we considered its pros and cons. Figure C2-1 shows one student's list of pros and cons for each security method. To narrow the choices, I had each student list the three security methods that he or she thought would work best. As one boy read these lists aloud to the class, another boy tallied the methods on the board. The whole class intently watched the tallying; many kept their own tally on paper. Figure C2-2 shows the tally results.

We looked at the results and decided to eliminate those security methods that received fewer than three votes. Another vote was taken and the following means of protection were chosen by the class:

		Number of Students
1.	Make lockers	2
2.	Make safes	3
3.	Make burglar alarms	5
4.	Make plastic lids to cover the tote trays	7
5.	Share tote trays, using one to hold personal items and the other to hold lunch boxes; make covers for the trays	11

Buy a safe ||| 3
Share tote tray ~~||||~~ ~~||||~~ || 12
Names in ink
Adhesive tape
tote tray in rak'e
plastic lid ~~||||~~ ~~||||~~ ~~||||~~ 15
make lockers ~~||||~~ || 7
Box locks ~~||||~~ | 6
By or make alarm ~~||||~~ || 7
Camera ||| 3
Breif case |||| 4
Bag with zipper |
guard
class can |||| 4
Put things away |||| 4
paint
sticker tape |

Figure C2-2

The class broke into five groups to work on these methods. I asked each group to draw their plans on paper and to compile a list of needed materials. The groups worked for the rest of this session and handed completed plans to me.

Later, as I looked at their sketches and lists, I noticed that no details were provided. For example, there were no dimensions indicated on the designs, and the list of materials did not specify size or amount needed. I raised this point when we next met. I explained that plywood was sold by sheets, Plexiglas was sold by the square foot, that hinges were of different sizes, and that there were many sizes and styles of locks, buzzers, bells, and batteries. We discussed the importance of drawing accurate pictures to help with building the item and to estimate its total cost. To determine cost of materials, I referred them to a J.C. Penney catalog. I also told them that they could use the telephone if they wanted to call stores. I returned the sketches and lists, and the groups proceeded to rework their plans.

The next day I gave a skill session on scale drawing. I used the example of a map scale, explaining that one inch on the map actually represented one mile. The class easily understood the session and proceeded to draw their designs to scale. Figure C2-3 shows one group's scale drawing of their safe.

To determine the total amount of materials and money needed for the class projects, we compiled a master list on the board. The first group gave the dimensions of their safe (four 5' x 2' sides and four 2' x 2' pieces for the top, bottom, and two shelves), the amount of plywood needed (56 sq. ft.), and the total cost ($12.32). The class was astounded by the cost. "We don't have that much money!" When all groups had reported, we determined that the total cost of the materials was about $40.00.

When we discussed the money issue, I reminded them that the Design Lab had some materials with which they could at least start their projects. The discussion then focused on how to raise money to replenish these materials. A few students felt that everyone should donate fifty cents. One boy felt that fifty cents was too little, that one dollar per person would be better. Many in the class, however, objected to bringing money. Some commented that their group would not need much money for their materials, and, therefore, if they donated money, they would be paying for someone else's project. Several students then asked why they could not have a bake sale. Others volunteered to bring

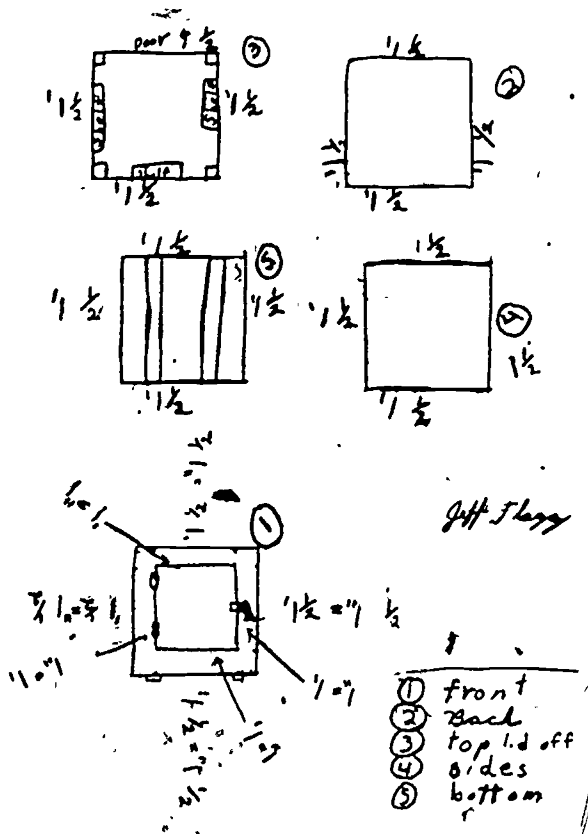


Figure C2-3

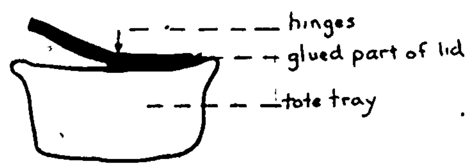
materials from home. This last idea was well received and was seen as being the most feasible. We decided that we would start the projects using the Design Lab materials and materials brought from home and would worry about raising money later if this was at all necessary.

For the next five weeks the class worked in the Design Lab constructing their lockers, safes, lids, and alarms.

The group making the Plexiglas lid for the tray ran into their first problem when they began cutting the Plexiglas with the saber saw; the Plexiglas began to melt due to the heat produced by the blade. The problem was resolved by switching to a handsaw.

To attach the lid to the tray, the group wanted to use the metal hinges that were available, but because of the curved tray edge, the hinges could not be attached. The group also noted that the pin connecting the hinge could easily be pulled out. They decided to use tape. I asked them whether tape was a good way to secure their tray. One girl felt that the tape would provide adequate protection because by the time someone got the tape off, they would be spotted by someone else. The other members accepted the tape solution because they claimed they could not think of anything else. I told them that I had great faith in their ability to think of a clever idea.

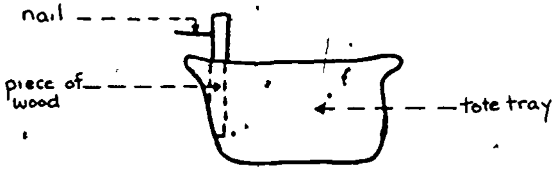
Five minutes later they excitedly called me back to tell me that they had figured out a way to attach the lid. They would saw the lid in half and glue one half to the tote tray. Hinges would then be attached to the two lid pieces so that the second half lifted. The lid appeared as follows.



The shape of the tote tray again caused problems when the group was ready to install a latch. The curved edge prevented the two latch components from getting close enough to latch. They decided that they needed to buy a larger latch. Since other students had already made latches for their safes and lockers, I suggested that they could perhaps do the same.

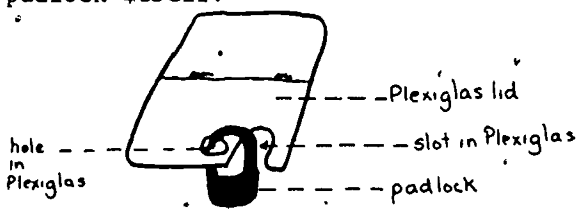
The group spent several days figuring out a latch design that would secure their lid to the tote tray. Instead of trying to attach a metal lock ring to the tray, they decided

to make a wooden hook, consisting of a long nail driven into a piece of wood. The piece of wood was then glued with Elmer's Glue to the inside of the tray front.

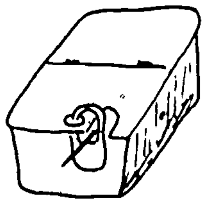


They soon discovered that the glue was not strong enough. They then used hot glue and C-clamped the wooden piece to the tray. The glue set all night, and when the C-clamp was removed the wooden lock ring remained tightly fastened to the tray.

In order to padlock the lid to the wooden lock ring, a hole and a small slot had to be made in the Plexiglas to allow for the padlock itself.



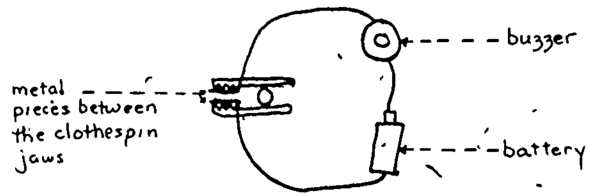
When this was done, the latched lid appeared as follows:



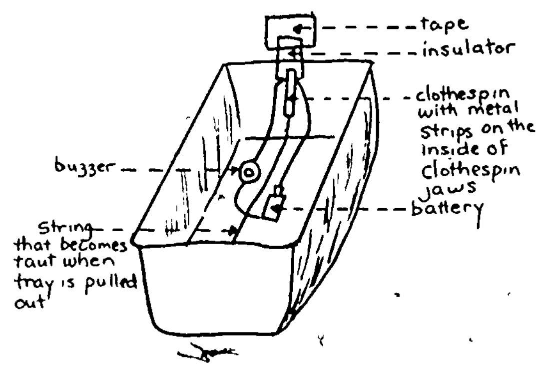
Later, the lid underwent a minor change. The padlock was too heavy for the lid; the lid's front edge slanted into the tray. The problem was resolved by moving the entire lid forward a little so that the padlock's weight was supported in part by the tray edge.

One group of boys who had installed an alarm in a tote tray expressed their concern to me that the alarm went off when they tried to get into the tote tray. I asked them whether they could make something like a light switch to turn the alarm off and on. One group member seemed confused, but another member quickly grasped what I meant and began explaining open and closed circuits to his group. Leaving the group, I left behind metal strips and a clothespin.

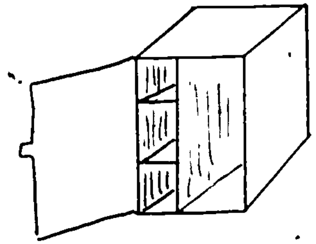
A week later the group completed an alarm that satisfied them. The alarm was set up so that when the tote tray was pulled out of the tray rack, the buzzer sounded. A clothespin was used as a switch. Metal pieces were glued to each inner jaw. Wires leading to the buzzer and battery were attached to the metal pieces inside the clothespin jaws. When the clothespin jaws were closed, the metal pieces came in contact, completing the electric circuit and sounding the buzzer.



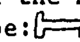
In order to keep the two jaws separated, the group inserted a piece of cardboard between the metal pieces in the clothespin jaws. The piece of cardboard was taped to the back of the tray rack, and the clothespin then hung vertically in the tote tray. One end of a piece of string was tied to the clothespin; the other end was taped to the front of the tote tray. When the tray was pulled out, the string became taut, making the clothespin move from its vertical position to a horizontal position. Further pulling of the tray eventually pulled the cardboard piece from between the clothespin jaws, making the two metal pieces come in contact, thereby completing the circuit and setting off the buzzer.

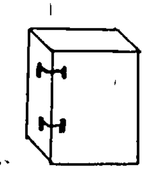


After drawing a plan, two girls constructed a Tri-Wall locker. They measured and cut the Tri-Wall pieces--four sides (one side being the door), a top, and a bottom. Instead of making a frame for their structure, they glued three sides at right angles to the top and bottom pieces. They also made shelves to store their small belongings.



To give the shelves more support, they cut slots into the sides of the locker. When they had installed the shelves, they tested their strength by weighting them with two coffee cans filled with nails, two hammers, and a power saw. The shelves held, but as a precaution the girls also put glue in the slot crevices.

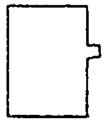
To install the door, they decided to buy large metal hinges, but they soon changed their minds when they examined the metal hinges on another girl's Tri-Wall locker and noted that the arrangement looked pretty flimsy and that the door did not open fully. They were at a loss as to what to do and came to me for ideas. I shared with them the idea of a Tri-Wall hinge that I myself had learned about at the USMES summer workshop. I explained to them that the hinge was made from Tri-Wall cut in the following shape:  . The center part was wrapped with masking tape to allow for flexibility. The two ends were glued to the side and to the door.



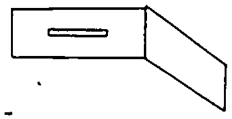
The girls liked this type of hinge and made three.

After putting the three hinges on their locker, they became concerned that someone could cut the hinges to break in. But they then reasoned that someone else would see anyone doing that. They decided that although their locker was not totally secure, it was more secure than the tote tray they were presently using. They added two more such hinges because the door was a little loose when they opened it.

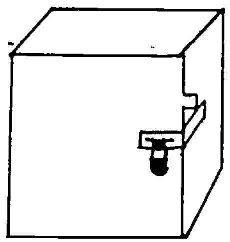
Before a latch could be put on the locker, the door had to be cut down, for it was wider than the door opening. They left a small section sticking out to act as a door handle.



The latch that they chose to make was devised by another girl who willingly showed them how she had made hers. A ten-inch long by two-inch wide Tri-Wall strip was cut and folded in half. A two-inch long slit was made in one of the halves as follows.

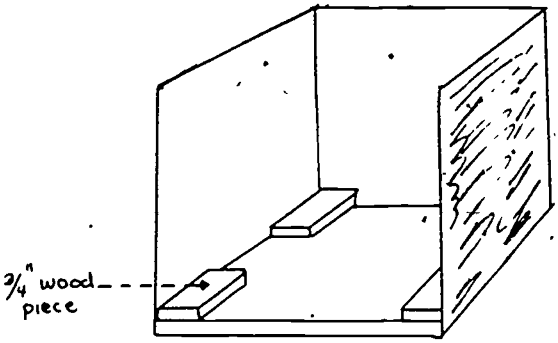


For the lock ring they bent a strong piece of wire into a horseshoe shape. The two ends of wire were stuck through the door. The ends were then bent so that they were flat with the door surface. Tape secured the ends. One end of the ten-inch Tri-Wall strip (without the slit) was glued to the locker side. The slit half of the strip was then slipped over the lock ring, and a padlock secured the locker door.

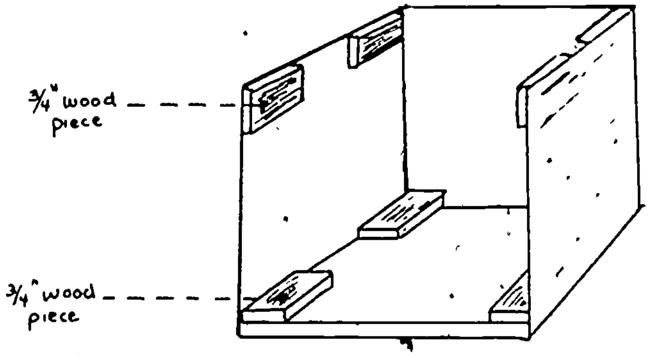


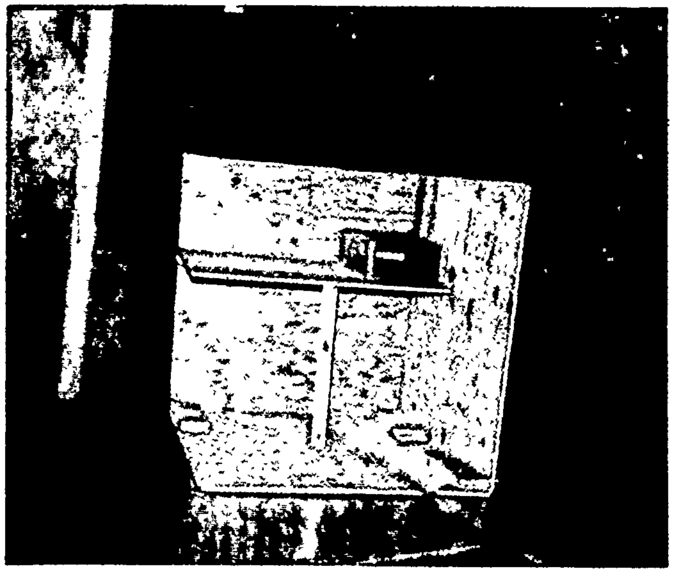
One group's plans were changed when they compared their plan (a four-foot tall locker) with the available wood. Instead, they decided to make a small safe. They cut all the pieces for their safe from quarter-inch plywood. They then tried to nail two pieces together at a right angle, a task they soon found impossible. I explained to them the purpose of a frame made from thicker pieces of wood (such as three-quarter-inch thick wood), that such a frame provided strength to the overall container and made it easier to nail the panels together.

Rather than making a frame per se, they proceeded to cut four short pieces of three-quarter-inch wood. These pieces were nailed to the floor of the safe as shown below.



The sides of the safe were then nailed to the three-quarter-inch pieces of wood. When they went to put on the safe top, they became confused because they had not put any three-quarter-inch pieces at the top of the safe's sides. When they returned to me, I explained that a frame was needed wherever they wanted to nail panels together. They then nailed two three-quarter-inch pieces of wood to each of the upper safe sides as shown below.

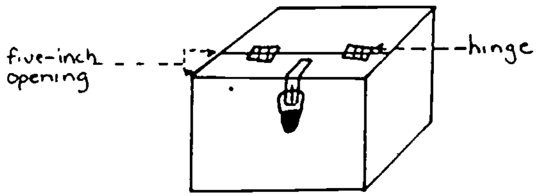




When the safe was completed except for the installation of the door, the group made a small Tri-Wall drawer in which to put their pens and pencils. They also made a box in which to store extra lunch money in case they forgot to bring their money one day. The two containers rested upon a shelf which was supported by small blocks of wood glued to the sides of the safe just beneath the shelf and a single piece of wood extending from the shelf center to the safe floor.

As the groups began assembling their lockers and safes, problems of inaccurate measuring and cutting became evident. One girl who had made a small Tri-Wall safe for herself discovered, while gluing the sides together, that one side was about three inches shorter than the other sides. She was upset because she didn't know how to fill in the resulting gap. One boy, noting her problem, helped her to cut a piece of Tri-Wall the size of the gap. The piece was then glued in.

One group discovered that the top panel of their safe was five inches shorter than the side panels, leaving a five-inch gap. At first they decided to cut all the sides down to match this smaller piece but then changed their minds. They designated the gap as a doorway. A piece of wood the size of the gap was cut. Metal hinges were put on the two pieces so that the front panel lifted up, and a metal latch and a padlock were used to secure the safe. The safe then appeared as shown below.



Another group discovered, upon gluing the lid on their safe, that there were one-inch gaps between the lid and the safe sides on both sides of the lid. They covered these gaps by gluing strips of Tri-Wall to the lid.

As the class worked in the Design Lab I noted that they quickly became comfortable working with the Design Lab tools. Most of them didn't hesitate a moment to use either the hand or power tools.

I also noticed a community spirit that the students developed. If someone needed assistance, such as having a

Richard
Jean
Paul

Problems we had

1 The wire would not work right, because it was to flimb.

2 When we pulled the totray out it would, it would not work until we pushed the top totray in.

3 Close pen would not stick with scotch tape.

How we solved the Problems

1 We tape the wire to a closepin

2 We lored the close pin behind the totray.

3 We got masking tape to stick the close pin behind the totray

Figure C2-4

board held or needing a new idea, most of the students willingly put aside their work to assist.

When the lockers and safes were completed, the students painted them. Some students encountered a little difficulty with this task. One boy wanted to paint an American flag on his safe but could not figure out an easy way to paint the stripes straight. I suggested that he use a ruler to mark off equal lengths at the top and at the bottom of a panel, starting at the same edge. When he connected a top mark to a bottom mark, he drew a straight line.

Another student complained that the paint he was using kept being soaked up by the wood. I suggested that he pour out some of the water and add more paint powder. He did this and corrected the problem.

To summarize their last few weeks of work in the lab, I asked each group to write down the problems they had had with their constructions and their solutions. Figure C2-4 shows one group's write-up.

The problem of where to put the lockers and safes arose naturally as groups completed their containers and began moving them from the Design Lab to our room. One group, whose locker was particularly large, put it in the open area between the fifth and fourth grades. Five minutes later they discovered that someone had poked a hole in the side facing the fourth grade. The group moved the locker to abut the sixth-grade open area, assuming that sixth graders were more responsible and mature and would not write on it or poke holes in it.

For other lockers and safes the class recommended the area between the tote tray racks. They also recommended stacking the smaller containers on top of the larger ones to save space. All agreed with both of these ideas until one boy pointed out that the safes and the lockers would be too close to the tote trays, preventing easy access. The students examined this situation and decided that the cause of this inaccessibility was not the safes and lockers but the desks and tables, which were too close to the tote tray racks.

The discussion then focused on ways to rearrange the desks and tables in the classroom. Several students' room rearrangement plans were diagrammed on the board for consideration by the class. I noticed that some of the students did not have a concept of the proportion of table size to floor space, and I asked these students how they could prove that their plan would work. One girl said that they needed to measure.

After measuring desks, tables, and floor space, they eliminated several plans for lack of space. Eventually we arrived at a plan that was popular with the class and also met my rule that everyone had to be able to see the board from their seat.

Spaces designated for the lockers and safes were measured, and those containers that fit within a particular area were placed accordingly. The smaller safes were put on top of the larger ones to conserve space.

The students felt quite confident that their safes, lockers, tote tray lids, and alarms would adequately protect their belongings.

Several weeks later we noted that nothing had been reported lost or taken. The students felt that this situation could be attributed to their security methods and to the fact that everyone was more careful in putting away their belongings.

3. MINI-LOG ON PROTECTING PROPERTY
Floor Alarm Design

by Charles Donahoe*
Dearborn School, Grade 4
Boston, Massachusetts
(November 1971-June 1972)

ABSTRACT

This group of six fourth-grade boys designed and constructed a floor alarm for the Design Lab in response to the problem of missing lab materials. The alarm was designed so that when someone stepped on a Tri-Wall doormat inside the lab door, two metal pieces came in contact with each other, completing the circuit and making a light go on in their classroom across the hall. After the alarm was finished, the group spent considerable time diagnosing and correcting short circuits. Eventually an improved floor alarm was made, but this too was found to have problems. The school year ended before they were able to make further improvements to their alarm.

A Protecting Property problem emerged in the Design Lab several weeks after school began. Materials were being taken from the lab when I was in another part of the building. This situation also occurred on the day when I was not at the school. Many teachers used the Design Lab for non-USMES activities and would frequently close the lab door when leaving but would forget to lock it.

I discussed this problem with a group of six boys who had been working in the Design Lab since the beginning of school on electric circuits and burglar alarms.** Because they had just built simple switches, I felt that they would be able to help me solve the Design Lab problem.

After we had examined and discussed each boy's switch, I asked them if they could think of any way to make an alarm using a switch. (This was not the first time I had talked

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**The unit challenge at that time was, "How can you design and build at reasonable cost a burglar alarm which would give effective warning?" Since then the challenge has been broadened to include other means of protecting property, such as lockers or safes, advertisements announcing the fact that alarms are in operation, and random checks by people.--ED.

to the members of the group about making an alarm with a switch. I had discussed this with each boy individually and had told them to think about this possibility.) Two boys said "yes" but then could not tell us a plan. We looked at some of the switches again, and I asked them what they had to do to make the switch work. One boy replied, "Push the switch down so that the two parts make a contact." As this observation still produced no ideas, I asked further questions.

"Can we expect someone to push the alarm down for us if they enter the room?"

"No!"

"How can we set the switch so that the burglar will help us out?"

(No response.)

"What other parts of your body might set off the alarm?"

"Your foot?"

At this suggestion minds began to work. One boy picked up someone else's switch, put it on the floor, and stepped on it. It was crushed beyond simple repair and there was almost a fight. I quickly commented that perhaps we needed a different kind of a switch.

The discussion then returned to the way switches worked, that when the above switch had been stepped on (and broken) a complete circuit was made. As we talked, a new possible dimension for the alarm design was introduced when one boy suggested using "a board or something." Someone immediately got a board and placed it on top of a switch. Everyone was skeptical.

The board and switch then reminded me about something that had happened to me a few days before when I had gone to a store to get some leather scraps for the lab. I told the group that when I started to walk down the stairs into the shop a bell had suddenly gone off.

One boy quickly commented that it was an alarm. "When you hit the board it made the switch come together, and the bell went off." Someone then suggested that the group could make a smaller switch.

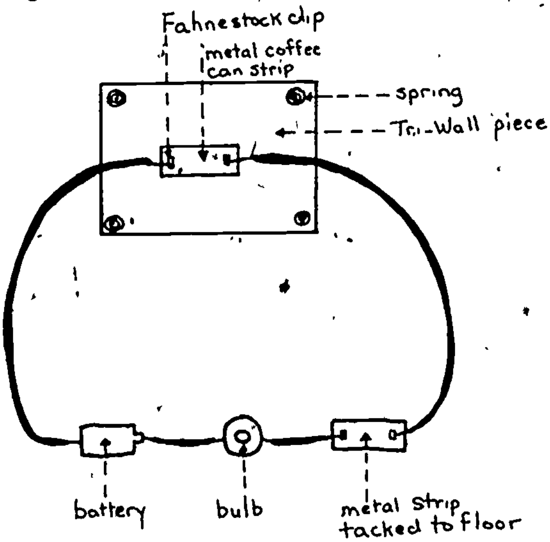
The boys proceeded to think of a suitable alarm design. One boy reminded the group that if the board were on the floor (on top of the switch) all the time, the switch would be on all of the time. The group thought about this for a few minutes until someone suggested using wooden blocks to raise the board off the floor. Before the group could really consider this suggestion, one boy, who had been sitting quietly, blurted out, "How about springs?" It took but a

few seconds for everyone to agree that this idea was a workable solution.

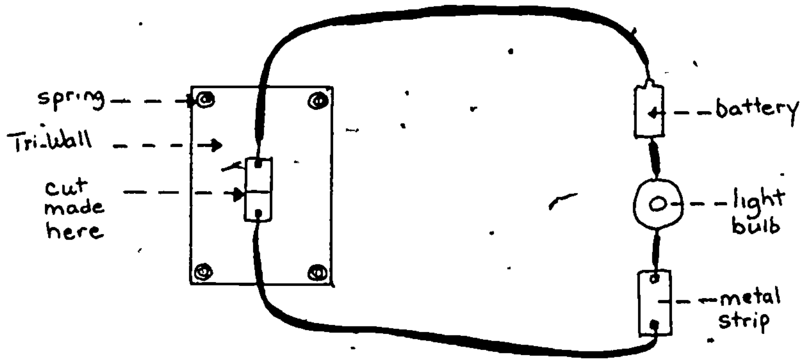
The students found some springs in the closet and glued one spring to each corner of a piece of Tri-Wall. When the hot glue had dried, they tested the springs by stepping on the Tri-Wall piece. The plan worked!

The group next had to decide where to place the switch. Two solutions were presented. One was to place the entire switch on the floor. The second solution was to put one part of the switch on the floor and the other part on the underside of the Tri-Wall piece. The second idea was chosen because the boy who offered it was the leader.

Metal strips were then cut from a coffee can. One strip was taped to the Tri-Wall, and another piece was tacked to the floor. Fahnestock clips were taped to each end of each metal strip to hold the wires leading to the battery and bulb. When the system was completed, it looked like the following diagram.

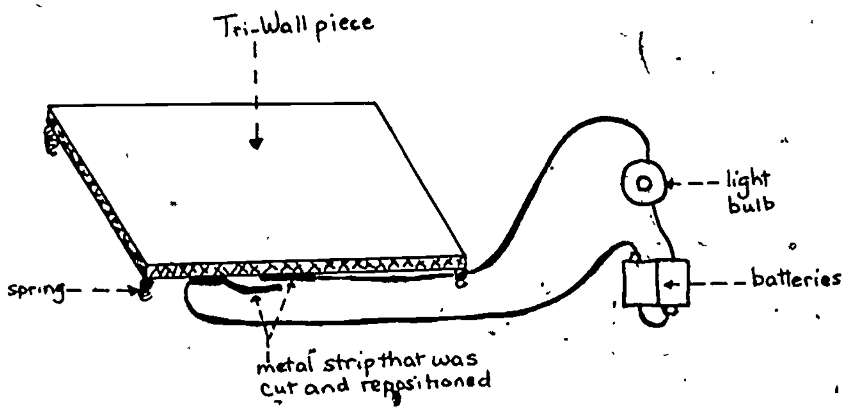


There were many puzzled expressions when we looked at the connected alarm: the light was constantly on. I asked several of the group members to trace the circuit for me. When they did this, the group realized that the circuit was complete. One boy said that the circuit needed to be cut. With that recommendation the metal strip under the Tri-Wall piece was cut in half as shown on the following page.



The alarm was put into working position, and one of the boys stepped on it. Success! Although they weren't sure why it worked, everyone was really happy.

A further modification of the metal strips was made when one boy suggested that there was no need for the metal piece on the floor. It was decided to modify the strip under the Tri-Wall and to eliminate the piece on the floor. The alarm then appeared as follows.



We then discussed where the light should be placed. Since the problem was to identify whether anyone was in the lab when I was not present, the group decided that the light should be placed in their classroom, which was across the hall from the Design Lab. One boy suggested that they use a dark, varnished wire so that it would be less visible in the hallway. Everyone agreed that this was a good idea and excitedly looked forward to the next session.

To decide which path the wire should take from the Design Lab to their classroom, we went into the hallway to look. Some of the boys wanted to run the wire straight across the hall, while others felt that it would be better if the wire followed the wall for a short distance before crossing over. Finally the group agreed that with the latter idea the wire was less noticeable. Three members volunteered to string the wire.

While these three boys worked on the wiring, two other members worked on the problem of securing the parts of their alarm. I asked them how they were going to secure the alarm. One boy suggested using hot glue, then changed his mind to staples, and finally decided to tape the switch to the floor. He got some masking tape, took the piece of Tri-Wall with the switch attached, placed it on the floor, and proceeded to push the Tri-Wall piece down as tight as possible against the floor, not realizing that he had pushed the two metal strips together. My asking him what he was doing quickly drew his partner's attention.

"Hey, don't do that."

"Why?"

"How's that gonna work? Why do you think we put the springs on there for?"

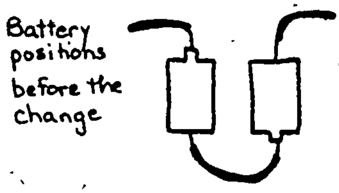
The other boy finally saw the problem and took the tape off. He then retaped the Tri-Wall piece so that it was not held tightly to the floor.

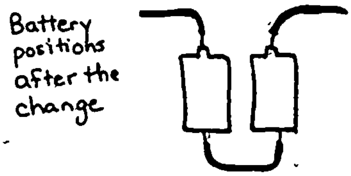
In the hallway the three boys stapled the wire to the hall baseboard. This was a slow and difficult task because the wires kept slipping before being stapled. In well-trod areas, such as a doorway that divided the hallway, the boys discovered that the staples did not hold the wire securely, and they used tape instead.

When all the necessary work--sanding the ends of the wire, making connections, hooking up the battery and the light in the classroom--was completed, they cheered when the light went on in the classroom. Someone asked, "Who's stepping on the alarm?" A check in the Design Lab showed no one standing on the Tri-Wall piece. There were many puzzled expressions.

We proceeded to diagnose the problem. One boy pushed down on the Tri-Wall; the light stayed on. They looked under the Tri-Wall to see whether the switch connections were making a permanent contact. They were not. One boy pulled the metal strips in the switch further apart, but the light remained on. Exasperated, they came to me and asked me why the alarm was not working as it should.

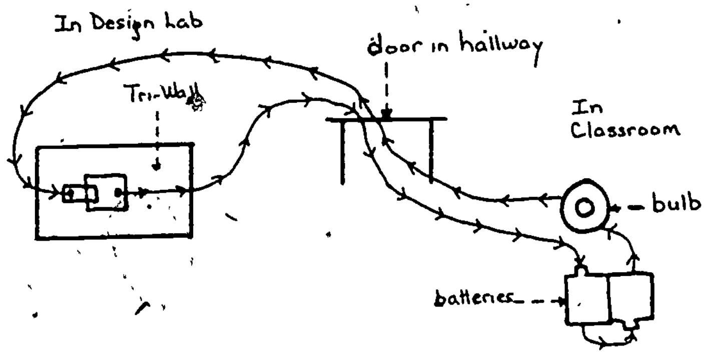
I told them to look over the whole alarm to see if they could figure out the problem. The switch, the wire in the hall, the batteries, and the light in the classroom were all thoroughly checked. One boy finally declared that the batteries were connected wrong. "That's the only thing that could be wrong." The wires on the batteries were switched and the light went out.





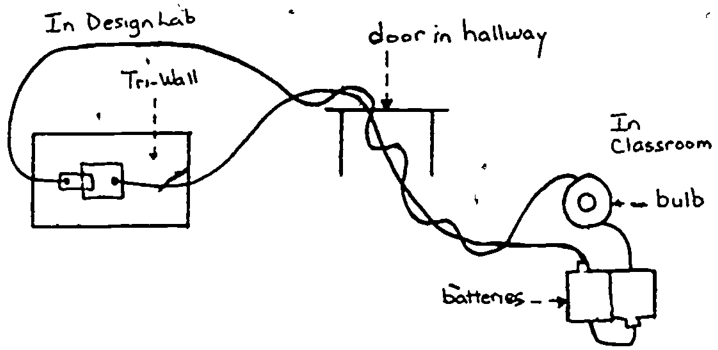
One boy quickly ran to the lab to step on the Tri-Wall. When he did, the light did not go on. (I think the boys knew that this arrangement of the batteries would not work because, when the light did not go on, they quickly returned the batteries to the original arrangement without my telling them to do so.)

Because they were out of ideas as to why their alarm was not working the way it was supposed to, I suggested that we return to the Design Lab to work further about the problem. On the board I drew a diagram of their alarm and asked one of the boys to trace the path of the current. He did this using arrows.

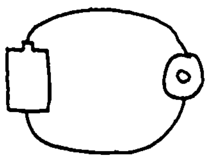


We looked at the completed diagram and agreed that there was a complete circuit present. I then asked them whether this diagram represented what the alarm really looked like. At first everyone said that it was exactly the same. I asked them to go back out to the hall and to look again. They did this, and two boys remarked that "the wires were

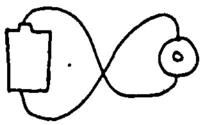
all twisted together." I drew another diagram of their alarm including the twisted wires.



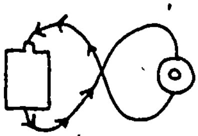
We looked at this second diagram, but no one made any comments. (I was hoping that someone would recall an earlier experiment that we had done on short circuits.) I then asked two of them to connect together a battery, two pieces of bare wire and a bulb in a holder. They did so as shown in the sketch below.



I then asked one boy to cross the wires to see what would happen. When the wires were crossed and the light went out, the group was surprised. I drew a diagram of what had just occurred and again asked someone to indicate the flow of current, again using arrows.



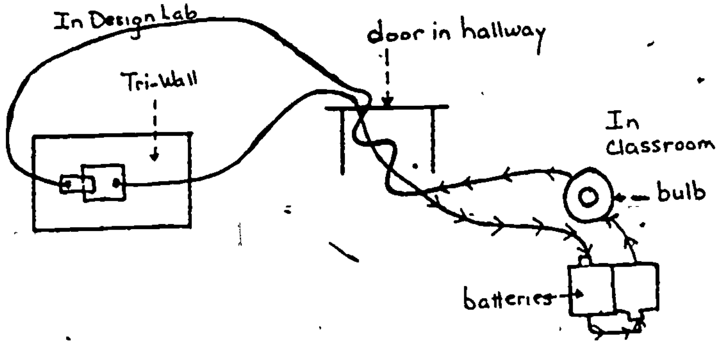
An argument ensued over which way the current went. One boy felt the circuit was still able to light the bulb. Two others argued against this idea, stating that the light did not go on, and therefore the current must have gone back to the battery. I asked them to feel the wires in different



locations on the circuit. All agreed that the wires were hot between the two ends of the battery but not between the two ends of the bulb holder.

We then returned to the original diagram of our alarm system with the twisted wires. One boy claimed that they had not used bare wire, but another admitted seeing places along the wire where the coating had worn off. We decided to recheck the wire.

Everyone checked the wire and found numerous places where the coating had been accidently scraped off. I then asked everyone to look at the diagram again and to explain what had happened. I picked a place on the diagram where the wires were crossed and asked them to indicate with arrows what had occurred. One boy volunteered and drew the following current path.



The group quickly returned to the hallway and proceeded to separate the wire. After they separated and jiggled the wire a little, the light went off. They then took turns stepping on the Tri-Wall mat and watching the light go on and off.

The group was quite proud of their alarm system. For the entire system they had used the following materials:

- an 8" x 12" piece of Tri-Wall (any size could have been used)
- four small springs
- two metal strips (4" long) cut from coffee cans
- two Fahnestock clips
- two batteries
- one light bulb and holder
- #22 plastic insulated wire
- #26 varnished electrical wire

For the next several weeks the alarm wires had to be repeatedly untangled. As soon as they thought the wires had

been straightened out, someone would accidently hit them and they would have another short circuit. During those times when the alarm was operating, I asked the group to use the floor alarm to count the number of people who entered and left the Design Lab during a day and a week. They were very interested in finding out this information and were very disappointed when the alarm was not working.

Eventually the floor alarm underwent some improvements by the original group of six boys, plus a few newly interested students. We discussed the old alarm, how it worked and the faults it had. Some of their suggestions for improving the system included--

1. do away with the varnished wire, use plastic insulated wire

2. reroute the path that the wire followed in the hallway

3. replace the Tri-Wall piece with plywood

4. replace the light bulb with a buzzer or bell

The second suggestion was quickly eliminated when they talked about other possible routes and could not arrive at a better one.

The process of experimenting with different materials for the improved alarm took several weeks because our session time was cut to twenty minutes due to scheduling problems. But this situation did not seem to bother the students at all, and they eagerly worked on improving the floor alarm.

The improved alarm was basically the same design. The Tri-Wall piece was replaced by a larger piece of plywood. To conceal it, they placed a thin rug on top of the wood. Because the wire in the hall had caused so much trouble, they dismantled it and shortened the circuit. Plastic insulated wire replaced the varnished wire. The light bulb was replaced by a bell. This design proved to be more sturdy and worked every time someone entered and left the Design Lab.

As time passed, the group noticed that students could still get into the lab without sounding the alarm! A student either reached in and disconnected the system or jumped over the plywood doormat. Because school was soon going to be out for the year, they were unable to make further improvements in their floor alarm.

4. MINI-LOG ON PROTECTING PROPERTY
Protection of a Display Case

by John Limon*
Heatherwood School, Grade 6
Boulder, Colorado
(September 1974-February 1975)

ABSTRACT
This group of sixth graders worked on the problem of protecting their school store from vandalism. They first installed a padlock on the school store display case to protect supplies that were for sale during certain hours of the day. Further protection was then provided by the placement of a wooden rod inside the case that prevented the other sliding door from being opened. After toying with the idea of designing and installing an alarm, they decided that their security methods were adequate. This proved to be true when an attempt later in the year to get into the case was unsuccessful.

Wishing to reopen a school store that had been in operation the previous year, the class worked hard raising money to buy school supplies to sell to the students. When funds had been raised and the supplies purchased, the problem of protecting them arose. The supplies were kept in a glass display case which had been purchased with the profits of the previous school store from a local grocery store that was closing its bakery department. Several students volunteered to investigate ways to protect the supplies in the case.

For immediate protection the group decided to install a padlock. They mounted the padlock so that when it was closed, it covered the screws fastening it to the door frame. (The screws had to be hidden because they felt that someone could break in easily by removing the screws.) They also placed a long wooden rod inside the case to jam the other sliding door against the side of the case, preventing it from being opened.

After the above security methods were installed, the group debated whether a burglar alarm was also needed, and they discussed various types of alarms. Some of their ideas were elaborate, such as installing a pinball machine tilt switch that would set off a bell if the display case were jarred or moved. Another suggestion was to set up a light beam system similar to those found in museums. In the end,

*Edited by USMES staff

they reexamined their protection methods on the case and decided that they were sufficiently foolproof.

Their security methods were put to a real test in late February. One of the students rushed into class and excitedly told that someone had broken into the school store the previous evening. He related that during the basketball game some third and fifth graders had been seen looking through the display case. Naturally, the news was a big shock to all of us; we couldn't believe that the locking system we had devised had been breached. As we questioned the boy, we learned that most of his story was hearsay. I later talked with the two boys who had been identified, and it turned out that although they had tried to open the store case, the lock had prevented their entry. They did get into an open bin under the case, but it contained only empty boxes. This was the extent of the reported break-in. We were all pleased that the lock had withstood the amateur burglary attempt.

D. References

1. LIST OF "HOW TO" CARDS

Below are listed the current "How To" Card titles that students working on the Protecting Property challenge might find useful. A complete listing of both the "How To" Cards and the Design Lab "How To" Cards is contained in the USMES Guide. In addition, the Design Lab Manual contains the list of Design Lab "How To" Cards.

ELECTRICITY

EC 1 How to Make Simple Electric Circuits
EC 2 How to Check a Circuit by Tracing the Path of the Electricity
EC 3 How to Make Good Electrical Connections
EC 4 How to Find Out What Things to Use in an Electric Circuit
EC 5 How to Make a Battery Holder and Bulb Socket
EC 6 How to Make a Battery and Bulb Tester
EC 7 How to Find Out Why a Circuit Does Not Work
EC 8 How to Turn Things in Electric Circuits On and Off
EC 9 How to Find Out Why a Bulb Sometimes Gets Dim or Goes Out When Another Battery is Added to the Circuit
EC 10 How to Connect Several Things to One Source of Electricity
EC 11 How to Draw Simple Pictures of Electric Circuits

MEASUREMENT

M 2 How to Measure Distances
M 3 How to Measure Large Distances by Using a Trundle Wheel
M 9 How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit
M 10 How to Use a Conversion Graph to Change <u>Any</u> Measurement in One Unit to Another Unit

RATIOS, PROPORTIONS, AND SCALING

R 2 How to Make a Drawing to Scale
R 3 How to Make Scale Drawings Bigger or Smaller

A cartoon-style set of "How To" Cards for primary grades is being developed from the present complete set. In most cases titles are different and contents have been rearranged among the various titles. It is planned that this additional set will be available early in 1977.

2. LIST OF BACKGROUND PAPERS

As students work on UMSES challenges, teachers may need background information that is not readily accessible elsewhere. The Background Papers fulfill this need and often include descriptions of activities and investigations that students might carry out.

Below are listed titles of current Background Papers that teachers may find pertinent to Protecting Property. The papers are grouped in categories shown, but in some cases the categories overlap. For example, some papers about graphing also deal with probability and statistics.

The Background Papers are being revised, reorganized, and rewritten. As a result, many of the titles will change.

DESIGN PROBLEMS

DP 4 *Electromagnet Design* by Earle Lomon

ELECTRICITY

EC 1 *Basic Electric Circuits* (based on suggestions by Thacher Robinson)

EC 2 *Trouble Shooting on Electric Circuits* (based on suggestions by Thacher Robinson)

GROUP DYNAMICS

GD 2 *A Voting Procedure Comparison That May Arise in USMES Activities* by Earle Lomon

MEASUREMENT

M 3 *Determining the Best Instrument to Use for a Certain Measurement* by USMES Staff

M 5 *Electric Trundle Wheel* by Charles Donahoe

RATIOS, PROPORTIONS, AND SCALING

R 3 *Making and Using a Scale Drawing* by Earle Lomon

3. BIBLIOGRAPHY OF NON-USMES MATERIALS

The following books are general references that may be of some use during work on Protecting Property. The teacher is advised to check directly with the publisher regarding current prices. A list of references on general mathematics and science topics can be found in the *USMES Guide*.

Resource Books for Teachers

Elementary Science Study. *Batteries and Bulbs*. New York: Webster Division, McGraw-Hill Book Company, 1968. (Order from McGraw-Hill Distribution Center, Princeton Road, Hightstown, NJ 08520.)

Basic Electricity. (Volumes 1 and 2), New York, New York: John F. Rider Publisher, Inc. (116 West 14th Street, New York 11, NY), 1954.

Basic books on electricity that are written for the layman. Very comprehensible.

DC Electricity. (Volume 1), New York, New York: John F. Rider Publisher, Inc. (116 West 14th Street, New York 11, NY), 1961.

Resources for Children

Local Police Department--to find out about various protection methods, such as Operation Identification.

National Exchange Club provides a crime prevention kit that may be obtained by writing to Crime Prevention, P.O. Box 2672, Toledo, Ohio 43606 and asking for Your Personal Crime Prevention Kit.

4. GLOSSARY

The following definitions may be helpful to a teacher whose class is investigating a Protecting Property challenge. Some of the words are included to give the teacher an understanding of technical terms; others are included because they are commonly used throughout the resource book. These terms may be used when they are appropriate for the children's work. For example, a teacher may tell the children that when they conduct surveys, they are collecting data. It is not necessary for the teacher or students to learn the definitions nor to use all of these terms while working on their challenge. Rather, the children will begin to use the words and understand the meanings as they become involved in their investigations.

Circuit — A path through which electricity can flow if the path is continuous.

Closed Circuit — A circuit that provides a continuous path for electricity.

Open Circuit — A circuit that does not provide a continuous path for electricity.

Parallel Circuit — A circuit in which two or more electrical components (such as bulbs and buzzers) are connected so that the electricity divides into two or more paths.

Series Circuit — A circuit in which the electricity flows through all components along a single path.

Short Circuit — A low resistance path resulting in too much current that may damage those components in the path.

Comparative Shopping — A method for determining the best buy(s) by comparing the costs, quantities, and qualities of different brands of products. For example, comparing building materials for the lockers and safes, comparing materials for the alarms.

Conductor — Material that offers very little opposition to the flow of electricity and therefore is used to carry or conduct electricity.

Conversion — A change from one form to another. Generally associated in mathematics and science with the change from one unit of measure to another or the change from one form of energy to another.

Cost — The amount of money needed to produce or to purchase goods or services.

Current — The flow of electric charge. Technically, the rate of flow of electric charge through a conductor: how much electric charge passes through a given point in a circuit in a given amount of time. Measured in amperes (amps).

- *Alternating Current (AC)* — Electric current that flows first in one direction and then in the opposite direction in regular cycles. Most household current is AC.

- *Direct Current (DC)* — Electric current that flows in only one direction. Current from batteries is DC.

Data — Any facts, quantitative information, or statistics.

Electromagnet — See *Magnet*.

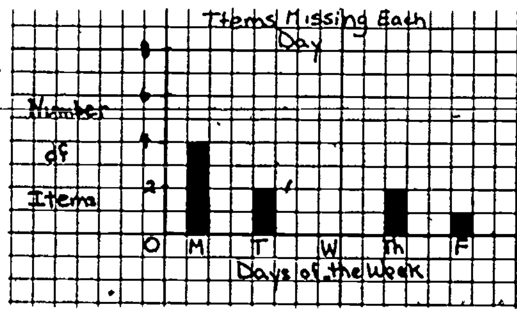
Event — A happening; an occurrence; something that takes place. For example, a theft.

Frequency — The number of times a certain event occurs in a given unit of time or in a given total number of events.

Graph — A drawing or a picture of one or several sets of data.

- *Bar Graph* — A graph of a set of measures or counts whose sizes are represented by the vertical (or horizontal) length of bars of equal widths. Example: number of items missing each day for one week.

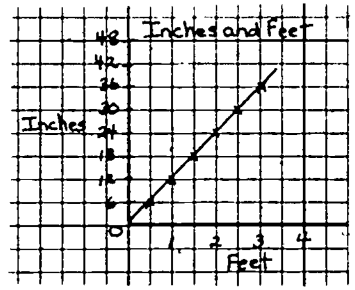
Day of the Week	Number of Items
M	4
T	2
W	0
Th	2
F	1



Conversion Graph

A line graph that is used to change one unit of measurement to another. For example, converting inches to feet for buying lumber.

Inches	Feet
6	1/2
12	1
18	1 1/2
24	2
30	2 1/2
36	3



Line Graph

A graph in which a smooth line or line segments pass through or near points representing members of a set of data. Since the line represents an infinity of points, the variable on the horizontal axis must be continuous. (If the spaces between the markings on the horizontal axis have no meaning, then the graph is not a line graph, but a line chart.)

Hypothesis

A tentative conclusion made in order to test its implications or consequences.

Inference

An assumption derived from facts or information considered to be valid and accurate.

Insulator

A material that offers much opposition to the flow of electricity.

Magnet

Electromagnet

A coil of wire, usually wound on an iron core, that produces a magnetic field when current goes through it.

Permanent Magnet

A piece of hardened steel or other magnetic material that has been so strongly magnetized that it retains the magnetism indefinitely.

Resistance

The opposition that a device or material offers to the flow of electricity, measured in ohms.

Retail Price

The price level of goods sold in small quantity to the consumer.

Scale

A direct proportion between two sets of dimensions (as between the dimensions of a drawing of a container and those of the container itself).

Scale Drawing	A drawing whose dimensions are in direct proportion to the dimensions of the area or thing represented.
Scale Model	A three-dimensional representation constructed to scale.
Schematic	A circuit diagram in which components are represented by symbols.
Switch	A device for opening and closing a circuit.
Voltage	A measure of the electrical energy per unit charge in a circuit. For a given circuit, as the voltage increases, the current increases.
Watt	A unit of measurement of power (energy per unit of time or work per unit of time.) Although light bulbs are rated in watts, the wattage indicates both heat and light output.
Wire Gauge	AWG (American Wire Gauge)--a system for numbering wire sizes; the larger the AWG number, the smaller the diameter of the wire.

E. Skills, Processes, and Areas of Study Utilized in Protecting Property

The unique aspect of USMES is the degree to which it provides experience in the process of solving real problems. Many would agree that this aspect of learning is so important as to deserve a regular place in the school program even if it means decreasing to some extent the time spent in other important areas. Fortunately, real problem solving is also an effective way of learning many of the skills, processes, and concepts in a wide range of school subjects.

On the following pages are five charts and an extensive illustrative list of skills, processes, and areas of study that are utilized in USMES. The charts rate Protecting Property according to its potential for learning in various categories of each of five subject areas--real problem solving, mathematics, science, social science, and language arts. The rating system is based on the amount that each skill, process, or area of study within the subject areas is used--extensive (1), moderate (2), some (3), little or no use (-). (The USMES Guide contains a chart that rates all USMES units in a similar way.)

The chart for real problem solving presents the many aspects of the problem-solving process that students generally use while working on an USMES challenge. A number of the steps in the process are used many times and in different orders, and many of the steps can be performed concurrently by separate groups of students. Each aspect listed in the chart applies not only to the major problem stated in the unit challenge but also to many of the tasks each small group undertakes while working on a solution to the major problem. Consequently, USMES students gain extensive experience with the problem-solving process.

The charts for mathematics, science, social science, and language arts identify the specific skills, processes, and areas of study that may be learned by students as they respond to a Protecting Property challenge and become involved with certain activities. Because the students initiate the activities, it is impossible to state unequivocally which activities will take place. It is possible, however, to document activities that have taken place in USMES classes and identify those skills and processes that have been used by the students.

Knowing in advance which skills and processes are likely to be utilized in Protecting Property and knowing the extent that they will be used, teachers can postpone the teaching

of those skills in the traditional manner until later in the year. If the students have not learned them during their USMES activities by that time, they can study them in the usual way. Further, the charts enable a teacher to integrate USMES more readily with other areas of classroom work. For example, teachers may teach fractions during math period when fractions are also being learned and utilized in the students' USMES activities. Teachers who have used USMES for several successive years have found that students are more motivated to learn basic skills when they have determined a need for them in their USMES activities. During an USMES session the teacher may allow the students to learn the skills entirely on their own or from other students, or the teacher may conduct a skill session as the need for a particular skill arises.

Because different USMES units have differing emphases on the various aspects of problem solving and varying amounts of possible work in the various subject areas, teachers each year might select several possible challenges, based on their students' previous work in USMES, for their class to consider. This choice should provide students with as extensive a range of problems and as wide a variety of skills, processes, and areas of study as possible during their years in school. The charts and lists on the following pages can also help teachers with this type of planning.

Some USMES teachers have used a chart similar to the one given here for real problem solving as a record-keeping tool, noting each child's exposure to the various aspects of the process. Such a chart might be kept current by succeeding teachers and passed on as part of a student's permanent record. Each year some attempt could be made to vary a student's learning not only by introducing different types of challenges but also by altering the specific activities in which each student takes part. For example, children who have done mostly construction work in one unit may be encouraged to take part in the data collection and data analysis in their next unit.

Following the rating charts are the lists of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in Protecting Property. Like the charts, these lists are based on documentation of activities that have taken place in USMES classes. The greater detail of the lists allows teachers to see exactly how the various basic skills, processes, and areas of study listed in the charts may arise in Protecting Property.

The number of examples in the real problem solving list have been limited because the list itself would be unreasonably long if all the examples were listed for some of the categories. It should also be noted that the example(s) in the first category--*Identifying and Defining Problems*--have been limited to the major problem that is the focus of the unit. During the course of their work, the students will encounter and solve many other, secondary problems, such as the problem of how to display their data or how to draw a scale layout.

Breaking down an interdisciplinary curriculum like USMES into its various subject area components is a difficult and highly inexact procedure. Within USMES the various subject areas overlap significantly, and any subdivision must be to some extent arbitrary. For example, where does measuring as a mathematical skill end and measurement as science and social science process begin? How does one distinguish between the processes of real problem solving, of science, and of social science? Even within one subject area, the problem still remains--what is the difference between graphing as a skill and graphing as an area of study? This problem has been partially solved by judicious choice of examples and extensive cross-referencing.

Because of this overlap of subject areas, there are clearly other outlines that are equally valid. The scheme presented here was developed with much care and thought by members of the USMES staff with help from others knowledgeable in the fields of mathematics, science, social science, and language arts. It represents one method of examining comprehensively the scope of USMES and in no way denies the existence of other methods.

REAL PROBLEM SOLVING	Overall Rating
Identifying and defining problem.	1
Deciding on information and investigations needed.	1
Determining what needs to be done first, setting priorities.	2
Deciding on best ways to obtain information needed.	1
Working cooperatively in groups on tasks.	2
Making decisions as needed.	1
Utilizing and appreciating basic skills and processes.	1
Carrying out data collection procedures--observing, surveying, researching, measuring, classifying, experimenting, constructing.	1
Asking questions, inferring.	1
Distinguishing fact from opinion, relevant from irrelevant data, reliable from unreliable sources.	1

REAL PROBLEM SOLVING	Overall Rating
Evaluating procedures used for data collection and analysis. Detecting flaws in process or errors in data.	2
Organizing and processing data or information.	2
Analyzing and interpreting data or information.	2
Predicting, formulating hypotheses, suggesting possible solutions based on data collected.	1
Evaluating proposed solutions in terms of practicality, social values, efficacy, aesthetic values.	1
Trying out various solutions and evaluating the results, testing hypotheses.	1
Communicating and displaying data or information.	2
Working to implement solution(s) chosen by the class.	1
Making generalizations that might hold true under similar circumstances; applying problem-solving process to other real problems.	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

MATHEMATICS	Overall Rating
Basic Skills	
Classifying/Categorizing	3
Counting	2
Computation Using Operations:	
Addition/Subtraction	3
Multiplication/Division	-
Fractions/Ratios/Percentages	-
Business and Consumer Mathematics/ Money and Finance	3
Measuring	3
Comparing	3
Estimating/Approximating/Rounding Off	3
Organizing Data	2
Statistical Analysis	3
Opinion Surveys/Sampling Techniques	3
Graphing	3
Spatial Visualization/Geometry	3
Areas of Study	
Numeration Systems	3
Number Systems and Properties	3
Denominate Numbers/Dimensions	3
Scaling	-
Symmetry/Similarity/Congruence	-
Accuracy/Measurement Error/ Estimation/Approximation	3
Statistics/Random Processes/Probability	3
Graphing/Functions	3
Fraction/Ratio	-
Maximum and Minimum Values	-
Equivalence/Inequality/Equations	3
Money/Finance	3
Set Theory	-

SCIENCE	Overall Rating
Processes	
Observing/Describing	1
Classifying	2
Identifying Variables	1
Defining Variables Operationally	1
Manipulating, Controlling Variables/ Experimenting	2
Designing and Constructing Measuring Devices and Equipment	1
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	1
Measuring/Collecting, Recording Data	2
Organizing, Processing Data	2
Analyzing, Interpreting Data	2
Communicating, Displaying Data	2
Generalizing/Applying Process to New Problems	1
Areas of Study	
Measurement	2
Motion	-
Force	-
Mechanical Work and Energy	-
Solids, Liquids, and Gases	2
Electricity	1
Heat	3
Light	3
Sound	3
Animal and Plant Classification	-
Ecology/Environment	-
Nutrition/Growth	-
Genetics/Heredity/Propagation	-
Animal and Plant Behavior	-
Anatomy/Physiology	-

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

SOCIAL SCIENCE	Overall Rating
Process	
Observing/Describing/Classifying	1
Identifying Problems, Variables	1
Manipulating, Controlling Variables/ Experimenting	3
Inferring/Predicting/Formulating, Testing Hypotheses	3
Collecting, Recording Data/Measuring	2
Organizing, Processing Data	2
Analyzing, Interpreting Data	2
Communicating, Displaying Data	2
Generalizing/Applying Process to Daily Life	3
Attitudes/Values	
Accepting responsibility for actions and results	1
Developing interest and involvement in human affairs	1
Recognizing the importance of individual and group contributions to society	1
Developing inquisitiveness, self-reliance, and initiative	1
Recognizing the values of cooperation, group work, and division of labor	1
Understanding modes of inquiry used in the sciences, appreciating their power and precision	1
Respecting the views, thoughts, and feelings of others	1
Being open to new ideas and information	1
Learning the importance and influence of values in decision making	1
Areas of Study	
Anthropology	-
Economics	3
Geography/Physical Environment	-
Political Science/Government Systems	3
Recent Local History	3
Social Psychology/Individual and Group Behavior	3
Sociology/Social Systems	2

LANGUAGE ARTS	Overall Rating
Basic Skills	
Reading	
Literal Comprehension: Decoding Words Sentences, Paragraphs	3
Critical Reading: Comprehending Meanings, Interpretation	3
Oral Language	
Speaking	1
Listening	1
Memorizing	-
Written Language	
Spelling	3
Grammar: Punctuation, Syntax, Usage	3
Composition	3
Study Skills	
Using References and Resources	3
Outlining/Organizing	3
Attitudes/Values	
Appreciating the value of expressing ideas through speaking and writing	1
Appreciating the value of written resources	3
Developing an interest in reading and writing	3
Making judgments concerning what is read	3
Appreciating the value of different forms of writing, different forms of communication	1

Key: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

REAL PROBLEM SOLVING IN PROTECTING PROPERTY

Identifying and Defining Problems	• Students note personal things missing from their desks. • Students note that Design Lab tools are missing from the lab. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Deciding on Information and Investigations Needed	• Students decide to observe security methods used in public buildings. • Students decide to experiment with different electric circuits.
Determining What Needs to Be Done First, Setting Priorities	• Students decide to build alarms for their desks before starting on the Design Lab security problem. • Students decide to make drawings of their alarms before building them.
Deciding on Best Ways to Obtain Information Needed	• Students decide that the police station is a good place to obtain information on security methods. • Students decide that the "trial and error" method is the best way to build an effective alarm. • Students decide to collect catalogs from electronics supply outlets to see what materials are available.
Working Cooperatively in Groups on Tasks	• Students work in groups to build different types of alarms.
Making Decisions as Needed	• Students decide that they need a switch to turn the alarm on and off. • Students decide how to place the alarm so that the burglar cannot see it and disconnect it.
Utilizing and Appreciating Basic Skills and Processes	• Students measure distances in their desks to determine lengths of wire needed. • Students record the number of times their alarms work without being adjusted. • Students discover that large batteries last longer than small ones.

Utilizing and Appreciating Basic Skills and Processes (cont.)	• Students discover that short circuits produce hot wires and quickly drain the batteries. • Students make signs warning others that alarms are in operation. • Students draw accurate diagrams of their alarms. • Students recognize the effects of alarms on others. • See also MATHEMATICS, SCIENCE, SOCIAL SCIENCE, and LANGUAGE ARTS lists.
Carrying Out Data Collection Procedures--Opinion Surveying, Researching, Measuring, Classifying, Experimenting, Constructing	• Students experiment with different electric circuits and keep sketches of each with notes on its characteristics. • Students construct the alarms and install them. • Students measure length of wire needed. • See also MATHEMATICS list: *Classifying/Categorizing; Measuring.* • See also SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/Experimenting; Designing and Constructing Measuring Devices and Equipment; Measuring/Collecting, Recording Data.* • See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying; Manipulating, Controlling Variables/ Experimenting; Collecting, Recording Data/Measuring.*
Asking Questions, Inferring	• Students wonder why the alarms do not work. They infer from the hot wires that there is a short circuit. • Students wonder why some connections are not good ones. They infer that connections have to be made with bare wire and must be held together tightly. • Students wonder why some batteries last longer than others. They infer that big batteries last longer than small ones. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Distinguishing Fact from Opinion, Relevant from Irrelevant Data, Reliable from Unreliable Sources	• Students decide that if the alarm sounds each time they open the desk for five times, the alarm components are secure. • Students recognize that a radio or electrical store is a good source for information on electrical components, such as batteries, wire.

Evaluating Procedures Used for Data Collection and Analysis, Detecting Flaws in Process or Errors in Data	• Students evaluate each other's alarm systems in terms of design. Suggestions are made for improvements. • Students wonder whether several things can be wrong with a circuit. They agree to change one thing at a time. • See also MATHEMATICS list: *Estimating/Approximating/Rounding Off*.
Organizing and Processing Data	• Students list electrical components available from different stores. • Students list number of times alarms worked according to type of alarm. • See also MATHEMATICS list: *Organizing Data*. • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data*.
Analyzing and Interpreting Data	• Students decide which electrical components would be best to use in their alarm design. • Students decide which type of alarm is most durable. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing*. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.
Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected	• Students predict that placing a piece of cardboard between two contacts will prevent the alarm from sounding. • After several successful trials of one alarm design the students decide that it is effective. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling*. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses*.
Evaluating Proposed Solutions in Terms of Practicality, Social Values, Efficacy, Aesthetic Values	• Students evaluate other students' alarms in terms of effectiveness and cost.
Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses	• Students install their alarms, and one week later they evaluate their effectiveness (e.g., whether anything is missing).

Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses (cont.)	• Students discover that cardboard placed between any two connections in a circuit prevents the alarm from sounding. • Students try out various mechanical improvements to alarms to determine which method makes the alarm work the best. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Communicating and Displaying Data or Information	• Students show sketches of their alarms to help explain how they work. • See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Working to Implement Solution(s) Chosen by the Class	• Students continue to use their alarm systems to protect their property.
Making Generalizations That Might Hold True Under Similar Circumstances; Applying Problem-Solving Process to Other Real Problems	• Students apply knowledge about alarms to other problems in protecting property. • Students apply process of changing one thing at a time to other experiments they conduct. • See also SCIENCE list: *Generalizing/Applying Process to New Problems.* • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

ACTIVITIES IN PROTECTING PROPERTY UTILIZING MATHEMATICS

Basic Skills	
Classifying/Categorizing	• Identifying and categorizing the times of day that require increased surveillance. • See also SCIENCE list: *Classifying*. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Counting	• Counting the number of children who want to make various security devices. • Counting the number of times the alarm does and does not sound. • Counting the number of warning signs needed in the classroom, hallways. • Counting to read scales on meter sticks, tape measures. • Counting by sets to find scale for graph axes.
Computation Using Operations: Addition/Subtraction	• Adding one- or two-digit whole numbers to find total length measurement of the classroom, school hallway. • Adding or subtracting one- or two-digit whole numbers to increase or decrease a measurement on a security container. • Adding one- or two-digit whole numbers (minutes) when establishing times for random checks.
Computation Using Operations: Business and Consumer Mathematics/Money and Finance	• Adding and subtracting dollars and cents to perform cost analysis on a security container or an alarm design. • Comparing prices of building materials, such as plywood, Plexiglas, batteries. • Multiplying to find total cost of materials. • Dividing to find cost of an item or a certain amount of a material.
Measuring	• Using standard units (centimeters, meters) of measure to measure distances in the classroom and hallways, to measure container sides. • Converting from one unit of measure to another, e.g., meters to centimeters and vice versa. • See also SCIENCE list: *Measuring/Collecting, Recording Data*.

Measuring (cont.)	• See also SOCIAL SCIENCE list: *Collecting, Recording Data/ Measuring.*
Comparing	• Using the concept of *greater than* and *less than* to make comparisons. • Comparing sizes, e.g., size of items to fit into container with size of container; comparing various sides of the containers. • Comparing loudness of buzzers and bells. • Comparing the costs of container and alarm designs. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*
Estimating/Approximating/ Rounding Off	• Estimating the cost of various container and alarm designs. • Determining when a measurement is likely to be accurate enough for a particular purpose. • Estimating how high to place warning signs on the walls; arranging the layout of the sign. • Using approximations in constructing holders for the electric components. • Rounding off measurements when determining size of container or length of wire needed. • Estimating how big to make the security containers.
Organizing Data	• Ordering real numbers on a graph axis. • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data:*
Statistical Analysis	• Interpreting bar graphs. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*
Opinion Surveys/Sampling Techniques	• Conducting an opinion survey on effectiveness of security methods. • Evaluating survey methods and data obtained. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*

Graphing

- Using graphs to display data; making the graph form--dividing axes into parts, deciding on an appropriate scale.
- Representing data on graphs.
  - Bar Graph--number of items missing each day for a week.
  - Conversion Graph--converting inches to feet.
- See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data*.

Spatial Visualization/Geometry

- Drawing designs of security containers using geometric figures.
- Using the concept of *greater than* and *less than* to compare geometric figures, e.g., rectangles and squares.
- Measuring and constructing security containers using meter sticks.

Areas of Study

Numeration Systems

- Using the metric system (decimal system) to collect and record measurement data.
- Using the decimal system in calculating costs of materials, such as lumber, paint, and hinges.

Number Systems and Properties

- See *Computation Using Operations*.

Denominate Numbers/Dimensions

- See *Measuring*.

Accuracy/Measurement Error/Estimation/Approximation

- See *Measuring* and *Estimating/Approximating/Rounding Off*.

Statistics/Random Processes/Probability

- See *Statistical Analysis*.

Graphing/Functions

- See *Graphing*.

Equivalence/Inequality/Equations

- See *Comparing* and *Computation Using Operations*.

Money/Finance

• See *Computation Using Operations: Business and Consumer Mathematics/Money and Finance.*

ACTIVITIES IN PROTECTING PROPERTY UTILIZING SCIENCE

Process	
Observing/Describing	• Observing that items are missing from desks or cupboards. • Observing security methods used in public buildings. • Observing and describing the differences among various alarm designs and among different security container designs. • Describing possible ways things are taken from the desks, classroom, Design Lab. • See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying*.
Classifying	• Categorizing the different ways things can be secured, e.g., alarms, containers, random checks. • Categorizing various alarm designs, e.g., floor alarm, desk alarm, door alarm. • Categorizing different things that can cause circuits to break down. • Classifying circuits as series or parallel circuits.
Identifying Variables	• Identifying variables in alarm designs, e.g., durability, effectiveness, cost. • Identifying variables in electrical circuits, e.g., number and type of batteries and bulbs, layout of circuit (series or parallel), type of contacts, switches, signals (bell, buzzer, light). • Identifying variables in security container designs, e.g., size, durability, cost, type of latch or hinge used, use of plywood or Tri-Wall, etc. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Defining Variables Operationally	• Defining an effective security method as one that prevents loss of property and can be employed at reasonable cost. • Defining a reliable alarm as one that sounds each time the desk lid is opened. • Defining electrical connections as series or parallel connections. • Defining number, size, and type of components used in circuits.

Manipulating, Controlling Variables/ Experimenting	• Making mechanical changes to improve the durability of an alarm. • Experimenting with different electrical connections and components. • Trying various ways to situate the alarm components in the desk, on the door, etc. • Checking one component at a time to determine why an alarm has stopped working. • Experimenting with building materials for the security container, e.g., hinges, latches. • See also SOCIAL SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Designing and Constructing Measuring Devices and Equipment	• Constructing alarms and security containers. • Constructing things for the alarms, e.g., battery holders, bulb sockets, switches. • Constructing hinges and latches for the security containers.
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	• Inferring from the presence of hot wires that there is a short circuit present. • Predicting that simple and plain signs will be more effective as warning signs than colorful posters. • Hypothesizing that adding more batteries to a circuit will make a bell ring louder; trying out this hypothesis. • Hypothesizing that each component in turn may be the cause of an incomplete circuit; testing each one to determine if it is indeed the cause. • Making diagrams of alarms and security containers. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Measuring/Collecting, Recording Data	• Using different measuring instruments, such as tape measures, meter sticks, trundle wheel. • Reading measuring instruments accurately. • Measuring the container sides before cutting them out. • Measuring wire lengths for alarms, hallway lengths, etc. • Determining the cost of each part of an alarm or container. • Making sketches of electrical circuits that are tried out. • Recording the number of times the alarm does and does not work.

Measuring/Collecting, Recording Data (cont.)

- See also MATHEMATICS list: *Measuring*
- See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*

Organizing, Processing Data

- Organizing sketches of circuits tried out according to how well they worked.
- Organizing lists of materials needed according to type, such as Tri-Wall, lumber.

Analyzing, Interpreting Data

- Calculating total amount of wire, Tri-Wall, lumber needed.
- Determining which circuits, switches, etc., work the best.
- Calculating the total cost of each type of alarm or container.

Communicating, Displaying Data

- Drawing alarm and security container designs.
- See also MATHEMATICS list: *Graphing.*
- See also SOCIAL SCIENCE list: *Communicating, Displaying Data.*
- See also LANGUAGE ARTS list.

Generalizing/Applying Process to New Problems

- Applying one's knowledge about protecting property to other problems concerning protection of property, such as protecting bicycles.
- See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

Areas of Study

Measurement

- Using different measuring tools to collect linear measurements.
- See also MATHEMATICS list: *Measuring.*

Motion

Speed/Velocity

- Observing that objects at rest do not move until a force is exerted on them.
- Observing that electrically-run machines (saber saws, electric drills) are faster than hand machines.

Force	• Observing that force must be applied to hammer nails into wood. • Observing that machines multiply the force that is exerted, e.g., a hammer multiplies the force exerted by a person.
Weight	• Observing that weight is a force because of the earth's gravitational pull on objects. • Observing that weight (force) is centered at a certain spot in an object. • Observing that strength can be measured as resistance to another force/weight.
Mechanical Work and Energy	• Noting that work is done and energy expended when nails are hammered into wood. • Observing that electrical energy is converted into the mechanical energy of buzzers, bells, saber saws, electric drills. • See also *Motion* and *Force*.
Solids, Liquids, and Gases	
States of Matter	• Observing that glue is available in liquid or solid form with different properties. • Observing that a solid stick of glue is turned into a hot liquid glue by using a hot glue gun.
Properties of Matter	• Observing that certain materials are not practical or durable for use in alarm systems. • Observing that certain materials conduct electricity and others do not. • Observing that certain materials are attracted by an electromagnet and others are not. • Observing that the different properties of Tri-Wall, lumber, leather, and other materials make them useful for different tasks. • Observing that glues, lumber, paint, and other materials have particular odors. • Observing the effects of physical wear on materials.
Electricity	• Observing that electricity can light bulbs and that electrical energy can be transformed into light energy.

Electricity (cont.)	• Causing a bulb to light by making a circuit. • Observing that electricity does not flow through the insulation on a wire. • Observing that the light goes on when the switch is closed and goes off when the switch is open. • Observing that chemical energy stored in a battery can be transformed into electrical energy. • Observing that large batteries last longer than small batteries. • Observing that no current flows when both positive or both negative ends of two batteries with the same voltage are connected together. • Observing that bulbs burn brighter when more batteries are properly added to the circuit. • Observing that different bulbs require more or fewer batteries to operate at the same level of brightness. • Observing that adding more bulbs in series or adding a greater length of wire to a circuit reduces the flow of electricity--bulbs get dimmer. • Observing differences in the brightness of bulbs in a parallel circuit and a series circuit. • Discovering that short circuits are dangerous and produce hot wires that may burn fingers. • Observing that saber saws and other electrically powered devices go on when the switch is closed and go off when the switch is open. • Observing that electricity can be transformed into mechanical energy (saber saw, electric drill, etc.), into heat energy (glue gun, etc.), into chemical energy (battery charger).
Heat/Temperature	• Observing heat from wires in a short circuit. • Observing that some machines (glue gun, saber saw) generate heat when turned on as electrical energy is transformed into heat energy.
Light	• Observing that chemical energy of batteries can be transformed into electrical energy and then into light energy in a light bulb.
Sound	• Observing that sounds differ in tone, pitch, loudness, and quality. • Observing that a sound becomes less intense as it moves away from its source.

Sound (cont.)

- Observing that electrical energy can be transformed into sound energy (mechanical energy) in a buzzer or bell.
- Observing that an increase in the amount of electrical energy (supplied by batteries) results in an increase in the loudness of the buzzer or bell.

ACTIVITIES IN PROTECTING PROPERTY UTILIZING SOCIAL SCIENCE

Process	
Observing/Describing/Classifying	• Organizing and classifying sets of ideas or information. • Observing students' different habits of storing their personal things. • Observing the effects of buzzers and bells on others. • See also MATHEMATICS list: *Classifying/Categorizing.* • See also SCIENCE list: *Observing/Describing/Classifying.*
Identifying Problems, Variables	• Identifying differences in opinion on which security methods are most effective in protecting their belongings. • Recognizing that some things are more desirable than other things, and therefore need immediate protection. • Identifying the class's schedule (times when the class is in or out of the room) as being a variable that has to be considered. • See also SCIENCE list: *Identifying Variables.*
Manipulating, Controlling Variables/ Experimenting	• Conducting trials of various alarms to note effects on others. • Experimenting with different time schedules for random checks to determine a schedule that suits everyone. • See also SCIENCE list; *Manipulating, Controlling Variables/Experimenting.*
Inferring/Predicting/Formulating, Testing Hypotheses	• Inferring from the class discussion the things that need to be protected. • Predicting which security methods are best to employ in the classroom to protect their property. • Hypothesizing that the posting of signs about security methods will prevent losses. Testing hypothesis by posting signs and recording losses. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Collecting, Recording Data/ Measuring	• Recording numbers and types of items missing, security method being used, time of day when items are missed. • Collecting information on thefts that have occurred in the school and/or city.

Collecting, Recording Data/ Measuring (cont.)	• See also MATHEMATICS list: *Counting; Measuring.* • See also SCIENCE list: *Measuring/Collecting, Recording Data.*
Organizing, Processing Data	• Organizing data of items missing according to time missing and security methods being used. • Tallying survey data on the effectiveness of different security methods. • Tallying information on school and/or city thefts. • See also MATHEMATICS list: *Organizing Data.* • See also SCIENCE list: *Organizing, Processing Data.*
Analyzing, Interpreting Data	• Comparing quantitative data on city and/or school thefts. • Comparing security methods according to effectiveness in preventing losses. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing.* • See also SCIENCE list: *Analyzing, Interpreting Data.*
Communicating, Displaying Data	• Representing survey and other data on security method effectiveness on bar graphs. • See also MATHEMATICS list: *Graphing.* • See also LANGUAGE ARTS list.
Generalizing/Applying Process to Daily Life	• Being more careful in putting away personal belongings. • See also SCIENCE list: *Generalizing/Applying Process to New Problems.*
Attitudes/Values	
Accepting Responsibility for Actions and Results	• Working in small groups or individually to perform tasks; making sure that the tasks get done. • Scheduling children to conduct random checks. • Being responsible for class trips (e.g., police station, shopping center): arranging convenient times for both teachers and students, obtaining the necessary permissions.
Developing Interest and Involvement in Human Affairs	• Seeking ways to protect personal things. • Investigating factors that make children want to "borrow" items from others.

Recognizing the Importance of Individual and Group Contributions to Society	• Recognizing that they can change conditions in their classroom and/or school. • Recognizing and assessing the effects of their action on other students in the school.
Developing Inquisitiveness, Self-Reliance, and Initiative	• Conducting group sessions with some teacher assistance. • Learning to use different ways of obtaining needed information, e.g., opinion surveys, telephoning. • Increasing their knowledge of possible resource places, e.g., police department, retail stores, library. • Resolving procedural problems that may arise during the course of activities.
Recognizing the Values of Cooperation, Group Work, and Division of Labor	• Finding that work proceeds smoothly when everyone cooperates and shares.
Understanding Modes of Inquiry Used in the Sciences, Appreciating Their Power and Precision	• Identifying and defining the problem; being able to distinguish it from related but secondary problems. • Using scientific modes of inquiry to investigate and solve problems of protecting property. • See also MATHEMATICS and SCIENCE lists.
Respecting the Views, Thoughts, and Feelings of Others	• Considering all suggestions and assessing their merits. • Recognizing differences in values according to age, experience, occupation, income, interests, culture, race, religion, ethnic background. • Considering the opinions of others when considering ways to protect property; conducting an opinion survey or a class vote.
Being Open to New Ideas and Information	• Considering alternative ways of doing various tasks. • Asking other people for opinions, ideas, and information.
Learning the Importance and Influence of Values in Decision Making	• Recognizing that preferences for various security methods reflect the values of each individual. • Recognizing that people's values and feelings are equal to or more important than other considerations (such as cost) when change is proposed.

Areas of Study

Economics	• Investigating the costs of alarm and security container designs. • Gaining experience in comparative shopping for materials. • Comparing durability and cost of various designs.
Political Science/Government	• Investigating regulations and policies affecting planned security methods the class wishes to employ. • Investigating systems of administration and control. • Working with school authorities to implement security methods.
Recent Local History	• Investigating previous attempts to protect property in the classroom and/or in school. • Investigating whether incidence of missing items has increased recently, both in their room and/or the school.
Social Psychology/Individual and Group Behavior	• Recognizing and using different ways of approaching different groups, e.g., teachers, policemen, retail store people. • Recognizing the need for leadership within small and large groups. • Analyzing the effects of the class's security methods on other students in the school.
Sociology/Social Systems	• Considering the school as a whole (physical environment and other students) as a factor in implementing security methods. • Recognizing different social systems in different social groups, e.g., students, adults. • Recognizing that there are many different social groups and that one person belongs to more than one social group. • Devising a system of working cooperatively in small and large groups.

ACTIVITIES IN PROTECTING PROPERTY UTILIZING LANGUAGE ARTS

--Decoding Paragraphs	• Decoding words, sentences, and paragraphs while reading "How To" Cards on electric circuits; while reading catalogs on materials; while reading the yellow pages of the telephone book; while reading reference books on electricity.
Reading: Critical Reading--Comprehending Meanings, Interpretation	• Understanding reference books on electricity. • Obtaining factual information about ways to secure property.
Oral Language: Speaking	• Offering ideas, suggestions, and criticisms during discussions in small group work and during class discussions. • Explaining to the class how their alarms work, procedures used to build the security containers, the random checks schedule. • Conducting a simple one- or two-question opinion survey: reading the questions aloud, recording the show of hands. • Using the telephone to obtain information. • Using rules of grammar in speaking.
Oral Language: Listening	• Listening to other students' ideas, suggestions, and criticisms during class discussions. • Listening to resource people (e.g., policemen, retail store business persons), their suggestions, recommendations, and instructions.
Written Language: Spelling	• Using correct spelling in writing, e.g., making warning signs, labeling graphs, making the random checks schedule, etc.
Written Language: Grammar--Punctuation, Syntax, Usage	• Using rules of grammar in writing.

Written Language: Composition

- Writing to communicate effectively:
  - preparing warning signs.
  - preparing a schedule or a chart for the random checks.
  - writing down other children's opinions of various security methods.

Study Skills: Using References and Resources

- Using local stores and the police station and their personnel as resources for ideas.
- Using various written resources, e.g., telephone book, references on electricity, catalogs on materials.
- Using the "How To" Cards on specific skills when needed.

Study Skills: Outlining/Organizing

- Taking notes when visiting the police station, while using the telephone.
- Organizing a schedule for random checks.

Attitudes/Values

Appreciating the Value of Expressing Ideas Through Speaking and Writing

- Finding that a phone conversation evokes a response from people.
- Discovering that a written sign affects people's actions, e.g., prevents others from opening the classroom cupboard door.

Appreciating the Value of Written Resources

- Finding that desired information can be found in written resources, e.g., telephone book, catalogs.

Developing an Interest in Reading and Writing

- Willingly looking up information ~~on electricity, other~~ ways to protect property.
- Seeking out newspaper and magazine articles on local thefts and ways various security methods foiled robbers.

Making Judgments Concerning What is Read

- Deciding whether written material (e.g., warning signs) is appropriate, whether it says what it is supposed to say, whether it may need improvement.
- Deciding whether what is read in a catalog is applicable to their particular problem of building an alarm and security container.

Appreciating the Value of Different Forms of Writing, Different Forms of Communication	• Finding that spoken explanations are sometimes better than written ones, e.g., explaining how the alarm works. • Finding that a diagram helps one to remember the container or alarm design when building it.

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